# SCIENCE

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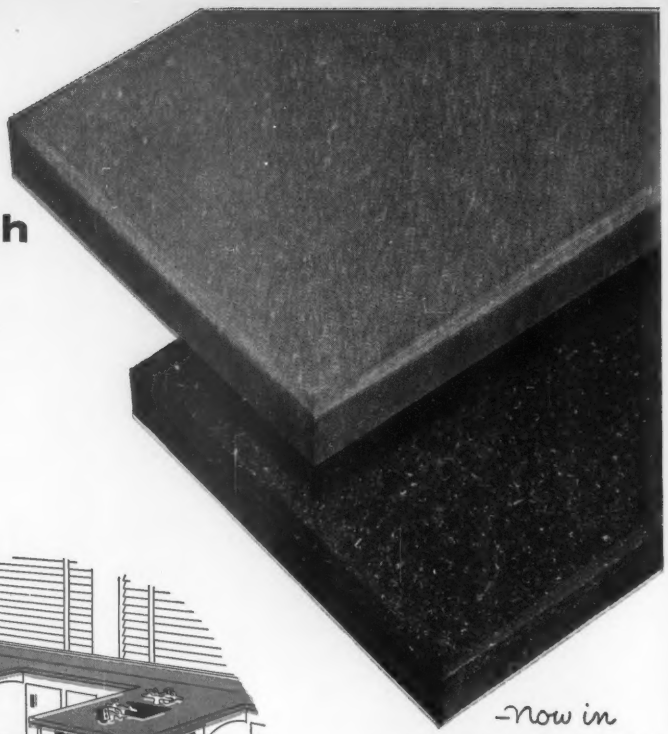

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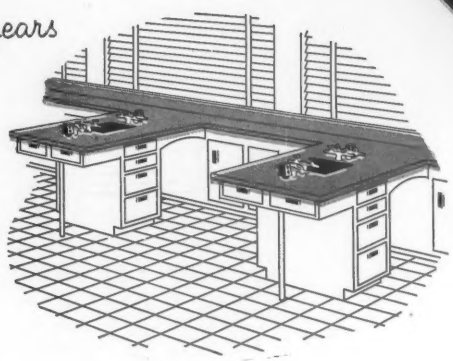

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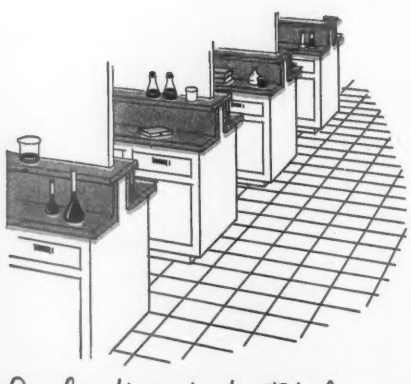

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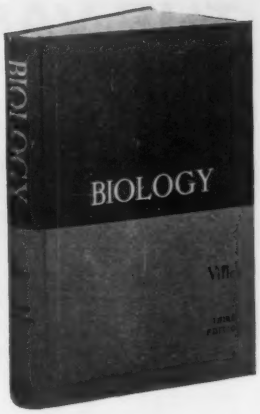


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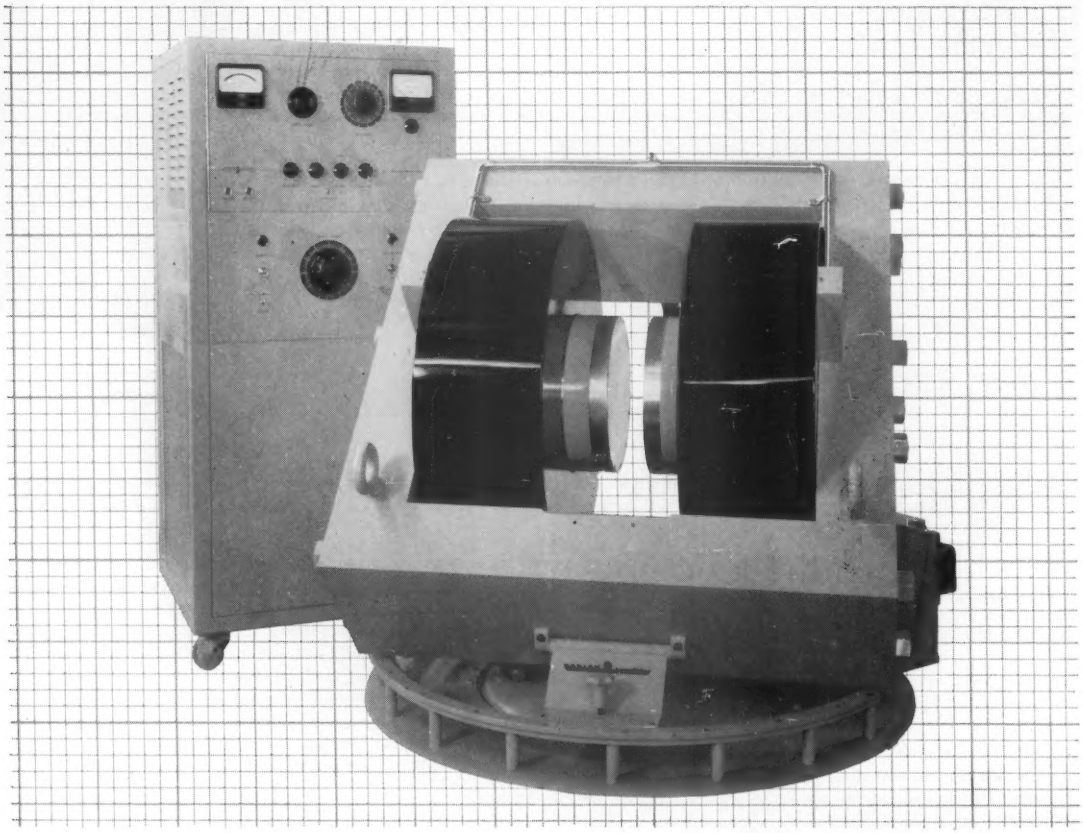

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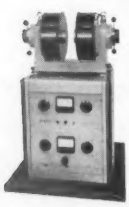

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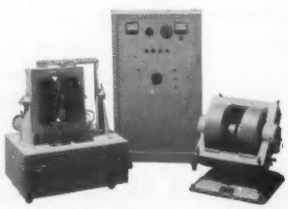

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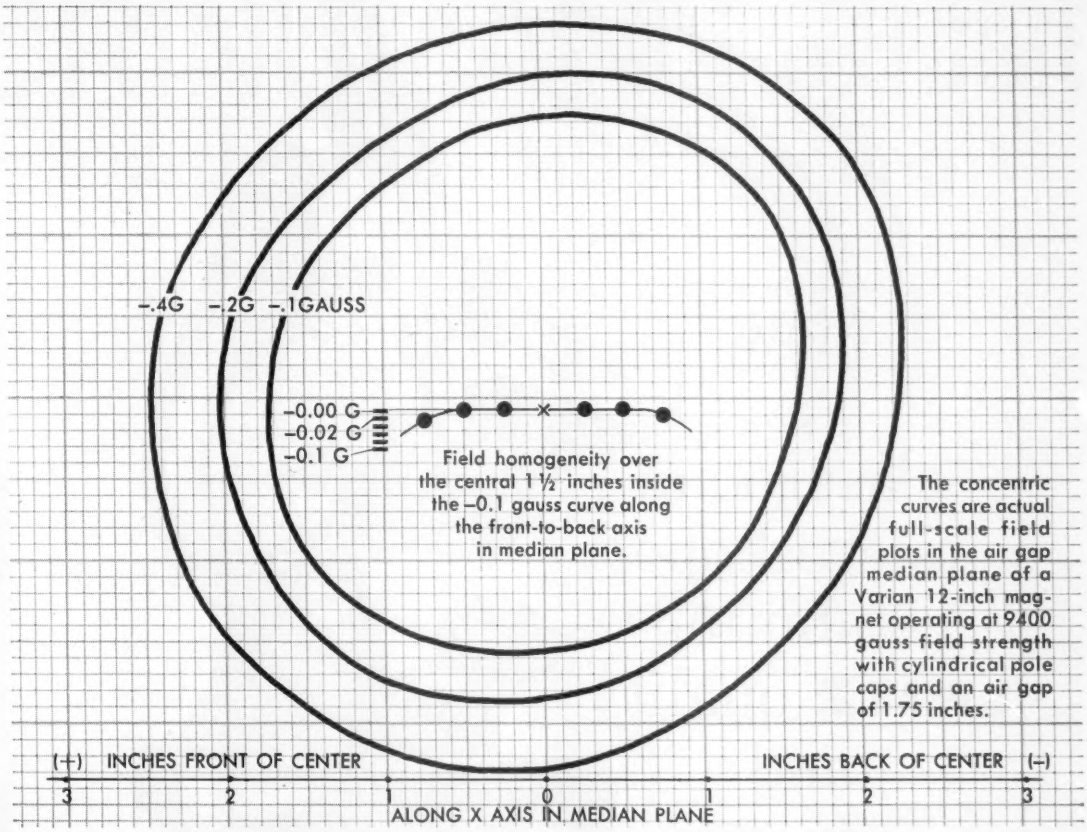
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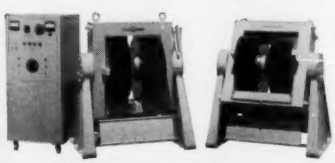

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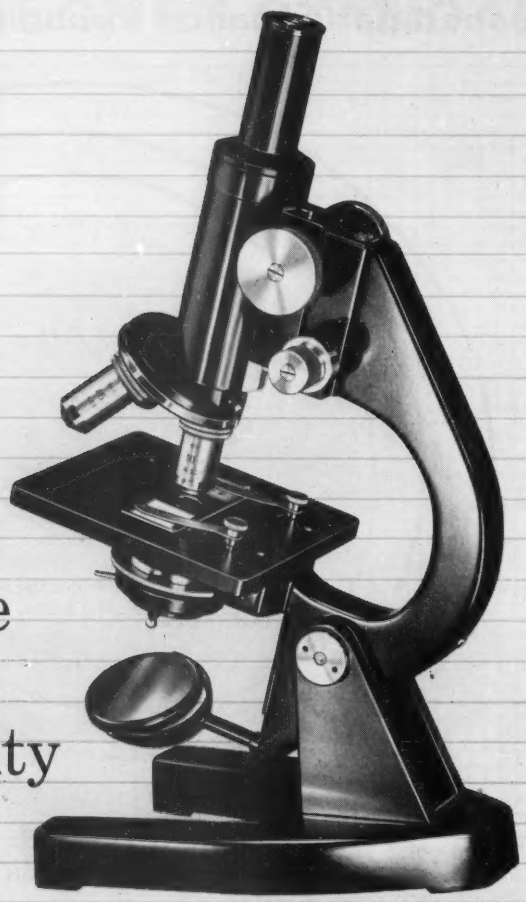

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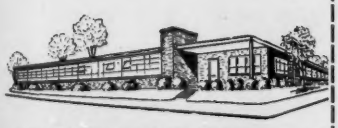

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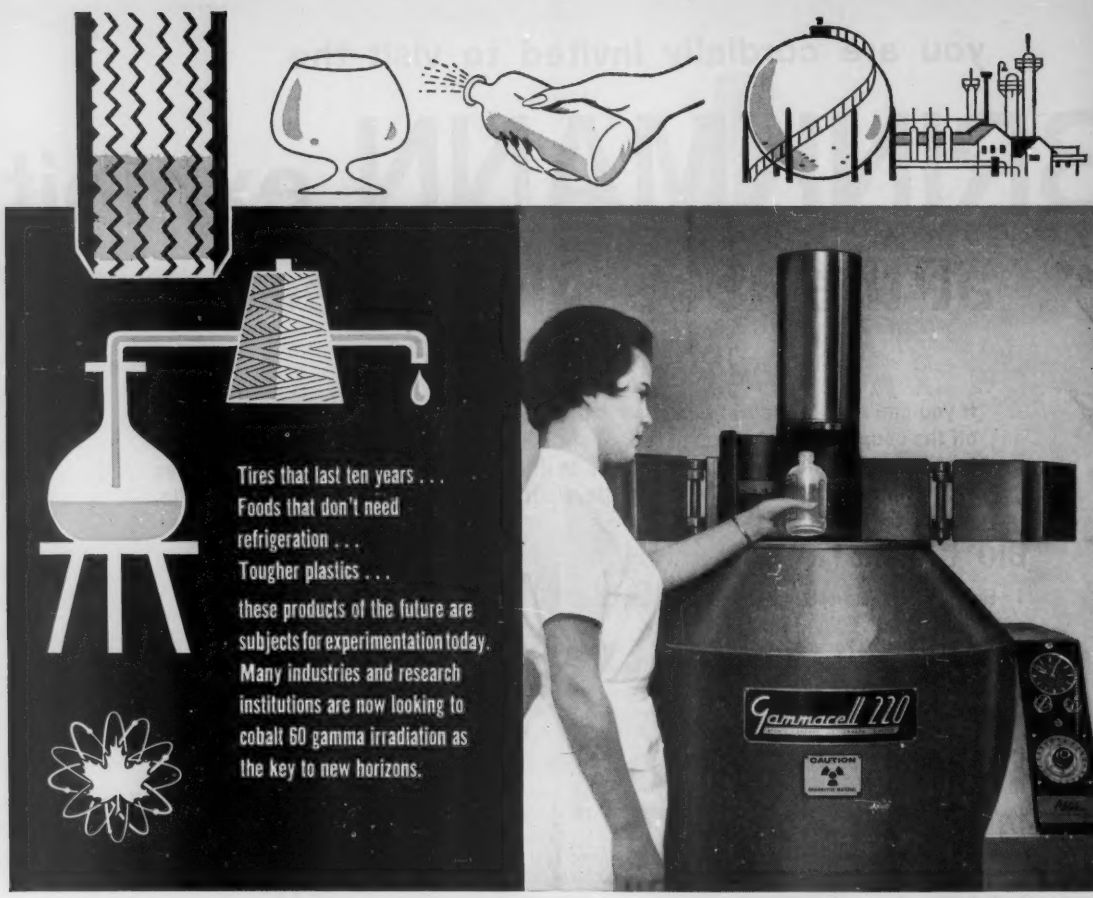
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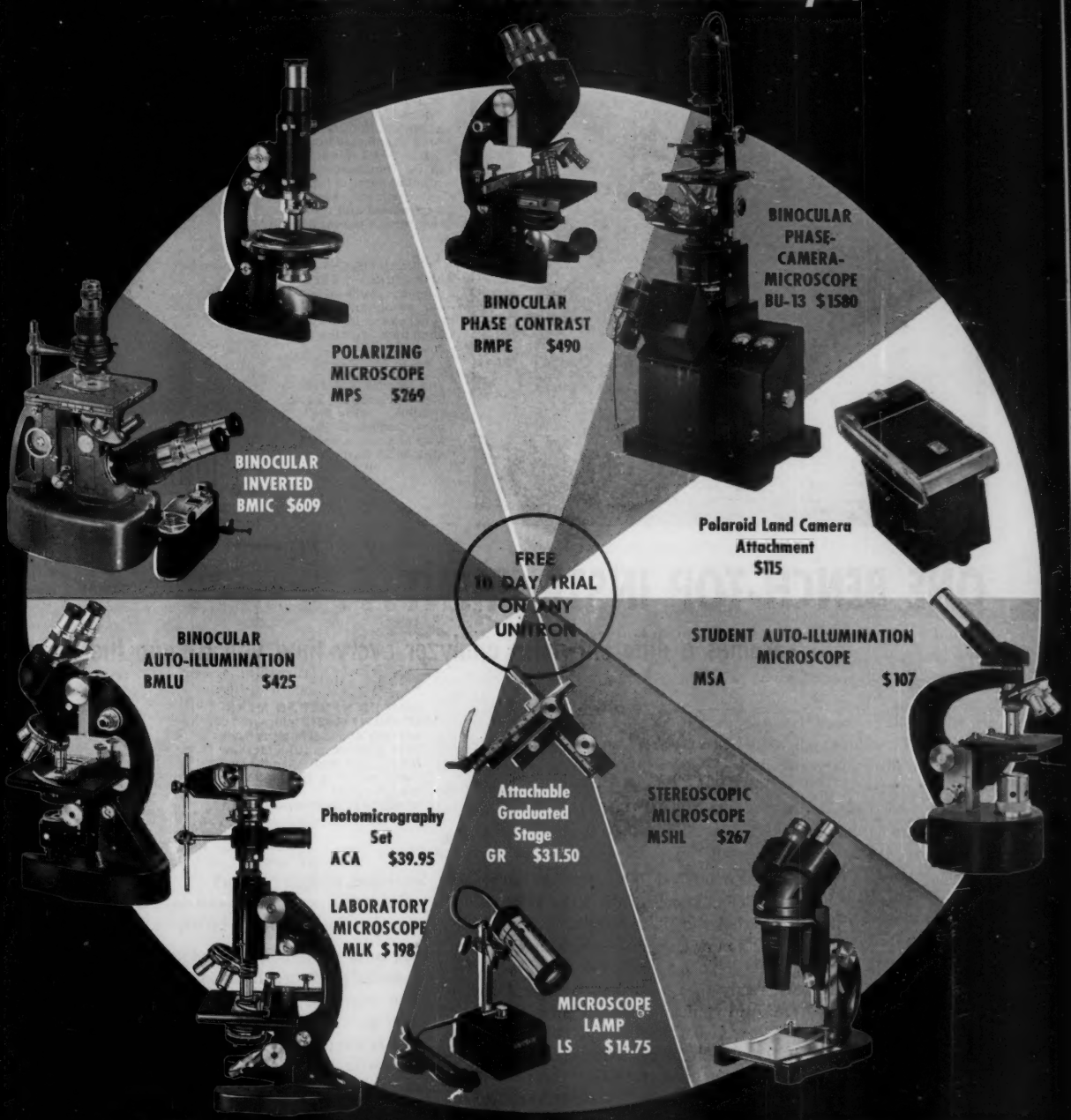
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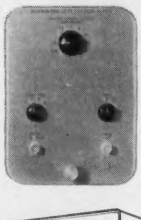

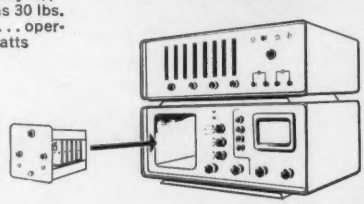

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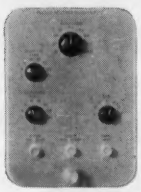

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## Far from the Madding Crowd

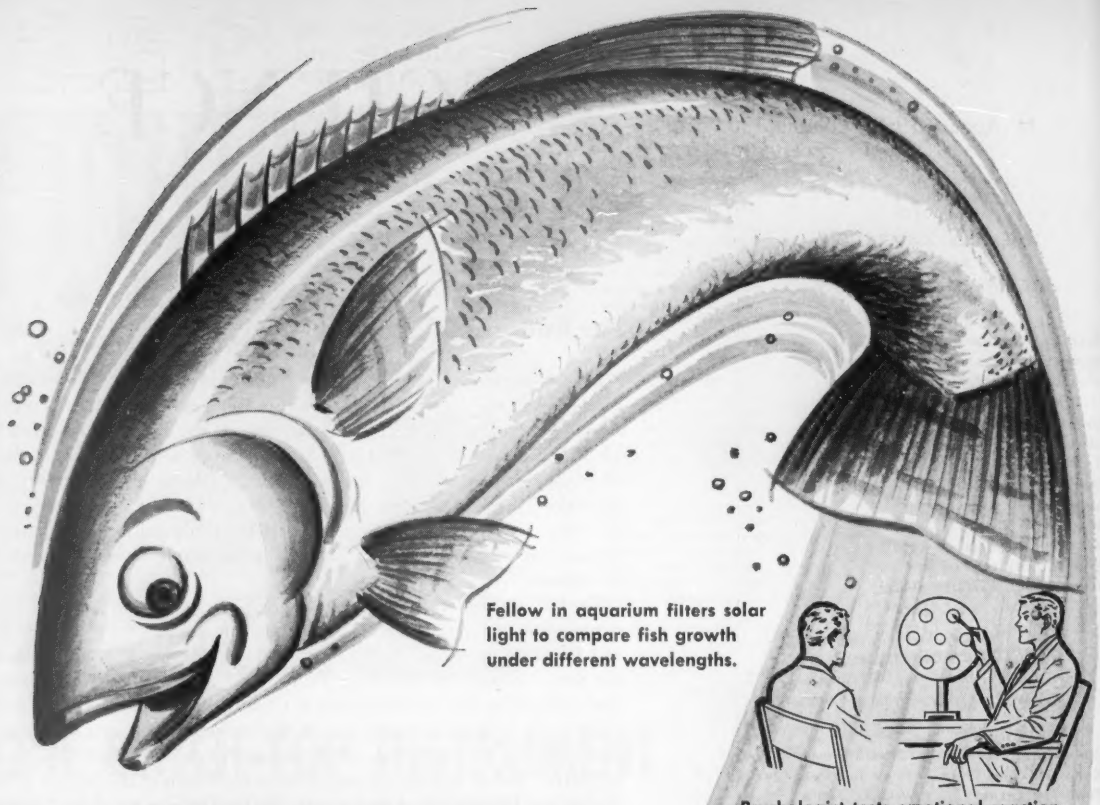
Most of the remaining wilderness in federal ownership—some 50 million acres—lies in the National Parks, Wildlife Refuges, and National Forests. A "wilderness area" is, for administrative purposes, an area considered to be in its primitive or primeval state. It has no roads, and access by any form of motor transport either by land or air is forbidden. In a bipartisan bill introduced in the Senate by Mr. Humphrey and 17 of his colleagues, a wilderness is "recognized as an area where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain."

The bill in question (S. 1123) is designed "To establish a National Wilderness Preservation System for the permanent good of the whole people, and for other purposes." It represents the culmination of a long fight on the part of conservationists to get a bill to the point of a vote in Congress. The first similar bill was introduced in 1956, and public hearings were held in 1957 and 1958. As a consequence of the hearings, the bill was modified to meet some of the objections of commercial interests—miners, stockmen, lumberers, and oil drillers—as well as other objections of the Bureau of the Budget, the Department of Agriculture, and the Department of the Interior. The bill was then reintroduced in 1958. After further hearings and additional revisions, the current version was introduced during the present session of Congress.

The current bill, if passed, will, among other things, make wilderness preservation a policy of Congress; it will allow the continuation of grazing in areas where grazing is now permitted at the discretion of the appropriate secretary, but will not allow extension to new areas; it will stop mineral leasing and prospecting unless the President determines that "such use or uses . . . will better serve the interests of the United States and the people thereof than will its denial"; it will leave the administration of the areas in the hands of the National Park Service, the Fish and Wildlife Service, and the Forest Service.

But the greatest change introduced by the bill is that the power of administrators (bureau chiefs and departmental secretaries) to add to, reduce, or abolish wilderness areas by executive order will be removed, and the final authority will be shifted to Congress. Any change proposed by an official will have to proceed by several steps: public notice for at least 90 days, hearings if demanded, and a report to Congress. If Congress fails to pass a joint resolution opposing the change after 120 days of continuous session, the change will take effect.

This bill is being considered today by the Senate Committee on Interior and Insular Affairs. If it is reported out favorably, which seems probable, there is a fair chance that it will be passed at this session. We hope so, for it is the best compromise bill that is likely to be worked out.—G.DuS.



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CURRENT PROBLEMS IN RESEARCH

# Domestication of Food Plants in the Old World

## Joint efforts by botanists and archeologists illuminate the obscure history of plant domestication.

Hans Helbaek

Due to an increasing interest shared by both archeologists and biologists in each other's spheres of activity, considerable research is being done today on problems of the interdependence between man and nature in the more remote past. This nature-man interdependence shows nowhere more clearly than in the quest of the cultural historian to grasp the effect, upon human society, of the domestication of animals and plants. Both natural and cultural historians are also concerned with nature's reaction to this drastic intrusion upon its domain (*1*). Recognition of the profound impact of the swing to food production and of its consequences in the development of human culture is of fairly recent date (*2*), but even so, cooperation between the two branches of science has already brought about a conspicuous improvement in understanding.

We shall confine ourselves here to considering the domestication of plants, and our area for discussion under the general heading "Old World" is, in this context, restricted to Europe, North Africa, and the temperate zone of western Asia to the Indus valley. This area is defined by the circumstance that all of the initial cultural developments and diffusions within it—from the appearance of the food-producing stage onwards—depended primarily upon the cultivation of wheat and barley for subsistence.

We shall also confine ourselves primarily to consideration of plant evidence which derives from the ancient archeological contexts themselves. This does not mean that we ignore the brilliant theoretical reconstructions of the histories of various domesticated plants offered by the botanical geneticists. The merit of the studies made by such workers as McFadden and Sears, Kihara, Müntzing, Schiemann, and N. Vavilov is self-evident. As a practicing paleoethnobotanist, however, I find my own approach to the problem of the appearance and early development of domesticated plants animated by one important principle. From the archeologically derived evidence itself, it is clear that any domesticated plant is an *artifact*, a product of human manipulation. Hence, rather than corresponding strictly to clear-cut genetic principles, the history of the domesticated plants seems to show various of the perversities of the manipulator, man himself.

The locus for the domestication of a wild plant must necessarily be its area of natural distribution. Thus, a prehistoric group of people, dependent upon wild wheat as its main food grain, must have developed its subsistence pattern within the boundaries of the natural distribution of that plant species. The same applies to any culture dependent upon barley. Now, as it happens, all primary (*3*) Old World agrarian cultures whose chief bread grains are known to us grew both wheat and barley together. Therefore, we can pin down the center of emergence of the wheat-barley cultures to the common area of distribution of the two plant species.

As may be seen on the map (Fig. 1), the wild, domesticable barley, *Hordeum spontaneum*, is distributed from Turkestan to Morocco (the distribution is represented in its broad outline only). On the other hand, the large-grained, wild wheat, *Triticum dicoccoides*, grows exclusively in a small natural area within the center of this huge territory. Thus, we may conclude from present distribution studies that the cradle of Old World plant husbandry stood within the general area of the arc constituted by the western foothills of the Zagros Mountains (Iraq-Iran), the Taurus (southern Turkey), and the Galilean uplands (northern Palestine), in which the two wild prototypes occur together. We may conclude, further, that wheat played a more dominant role than barley in the advent of plant husbandry in the Old World (*4*).

A basic prerequisite for the persistence of a wild plant is a natural ability to spread over a wide area. In wild grasses the spike becomes brittle at maturity and falls apart in spikelets containing the seeds, which are carried about by wind and animals. In some grasses, such as wild wheat and barley, there is a recessive tendency to develop toughness of the spike axis, and this circumstance was most advantageous to man. Instead of collecting unripe spikes, he could reap most of the fully mature grain, providing the spike had tough axes. At the same time he would, in harvesting, recover a steadily increasing proportion of the tough-axis spikes, thus also favoring the tough-axis genes in his seed grain. In the end, no brittle-axis plants grew in his field. The toughness attained in the primary issue of the wild wheat was not, however, as great as that of some of the genetically more advanced species. Even today the structurally primitive cultivated species, Einkorn, Emmer, and Spelt, exhibit a median stage of toughness between that of the wild ancestors and that of the free-threshing species, such as Bread wheat and Hard wheat.

Expressed in a few words, the impetus behind plant domestication is the human

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drive to secure the greatest possible amount of food with the least possible labor. The means by which this goal was attained with the food plants was the furtherance of growth by tilling of the soil, the concentration of the desired growth by sowing, the exclusion or removal of unwanted plants from the tilled plot, and the protection of the crop plants against animal and bird attack.

In order to perform these activities it must at an early stage have proved practical to move the wheat down from its exposed natural habitat on the mountain slopes, at altitudes between 2000 and 4300 feet above sea level, to more level ground. A nearness to open grasslands, domestic water supply, and other accommodations for human habitation was necessary, but it was still also necessary to stay within the boundaries of areas having sufficient winter and spring rainfall.

## Emmer and Einkorn

One result of this forced movement of the grain beyond its natural habitat by human transplantation was presumably the emergence of mutations, hybrids, and freaks in the wheat. A natural selection of types was begun which favored individuals that had no chance of free survival in the original habitat, and thus the biological and morphological course was set which resulted in the domesticated type of the wild *Triticum dicoccoides*, named *T. dicoccum* (Emmer). From this species all other species of cultivated wheat derive, with the exception of Einkorn, *T. monococcum*, which is the progeny of the small-grained wild wheat, *T. aegilopoides*. Neither of these species (Emmer and Einkorn) was able to survive without the care of man, their competitive powers having been stunted by the loss of their ability to disperse. On the other hand, man had become the servant of his plants in that his whole routine of life depended upon the steady and ample supply of vegetable food derived from his field.

Since as yet only one group of archeological finds, those at Jarmo, in Iraqi Kurdistan, affords the crucial combination of both the wild prototype and its more advanced domesticated issue, we will take Jarmo as our point of departure in this discussion. Jarmo is an early prehistoric site in the uplands of Iraq-Kurdistan, excavated by the Oriental Institute of the University of Chicago (*5–7*). The cultural assemblage is of a primitive, pre-Hassunan character; whether or not Jarmo is the earliest "village" or "town" type settlement known in archeology is of minor importance to us here (*8*). The main point is the fact that the wild cereals here make their earliest appearance in any known cultural context.

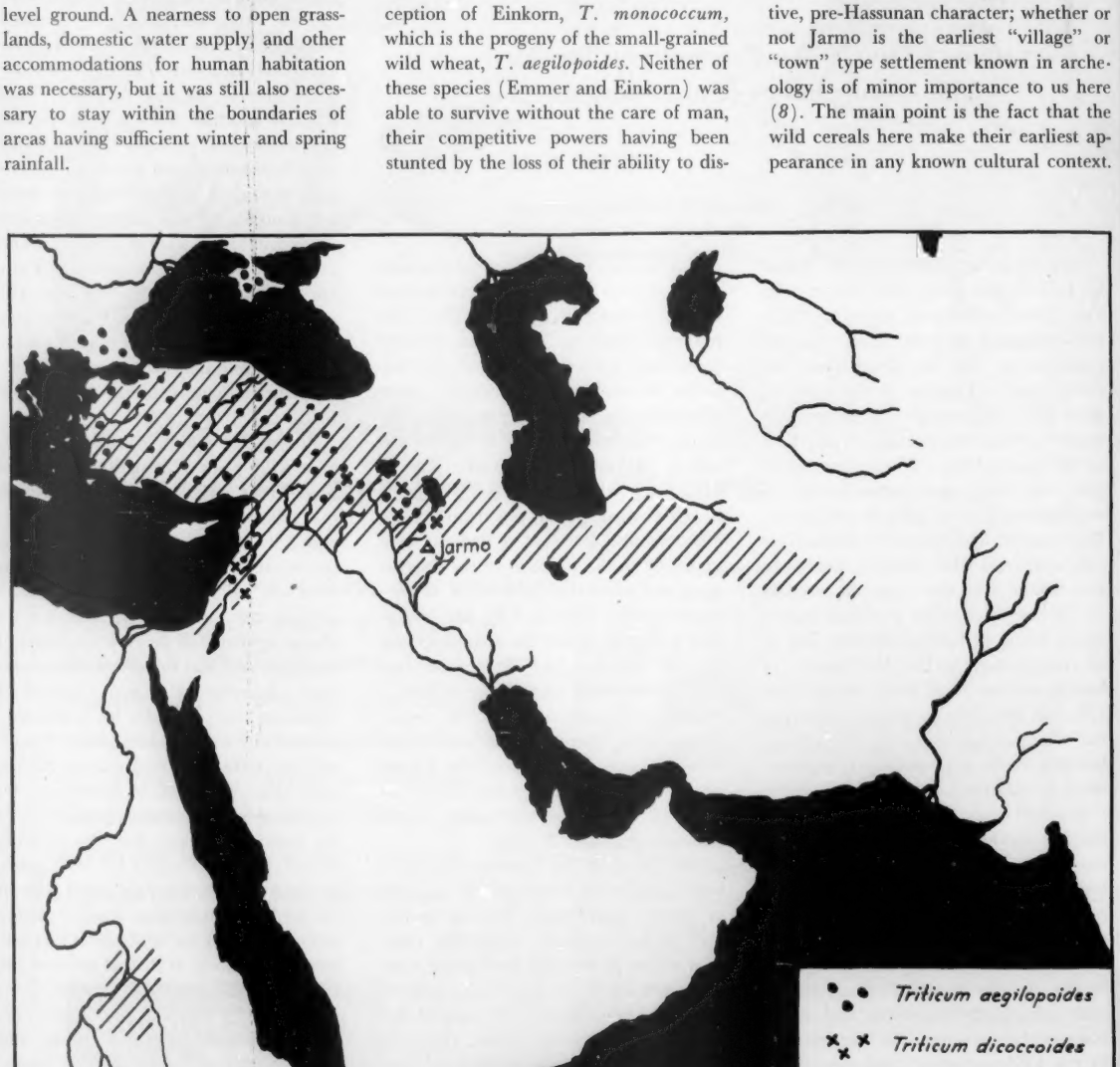


Fig. 1. Distribution of wild prototypes of cultivated wheat and barley. Wild barley is also distributed in western North Africa, beyond the bounds of this map.

The present estimate of the actual date of Jarmo is the beginning of the 7th millennium B.C.

The material recovered at Jarmo consists of imprints of grains and spikelets in baked clay and adobe, as well as carbonized grains and seeds and spikelets. In the carbonized material, evidence is available of two types of wild wheat kernels (Fig. 2): the straight, flat-bottomed type similar to *T. dicoccoides* and a smaller type with convexly curved ventral and dorsal sides, corresponding to *T. aegilopoides*. In the imprints we find very good examples of spikelets closely similar to *T. dicoccoides* (Figs. 3, 4), of large dimensions and rather coarse; on the other hand, the more advanced domesticated type, similar to Emmer, *T. dicoccum*, is represented in many specimens (Fig. 5), and also many kernels of the typical shape of Emmer are encountered in the carbonized grain. Thus, we are confronted at Jarmo with the two wild species which normally still occur together in the Kurdish localities, and further, with the offspring of the large-grained species, already characteristically transformed into Emmer (*9*). Incidentally, as in practically all other Near Eastern grain deposits (except those of Egypt), kernels and fragments of the sturdy glumes of *Aegilops* were present. In due course, the other components of the Jarmo plant deposit will be dealt with, but we shall now try to follow the spread and genetical development of the cultivated wheat.

In the 6th millennium B.C. (Hassuna period) village site of Matarrah, still in the Kurdish uplands but at a lower elevation than Jarmo (*6, 10*), we find only the cultivated Emmer. Whether or not Einkorn was also grown here has not been established. The Halafian communities of the upper Euphrates-Tigris region appear to have grown mainly Emmer, with a sprinkling of Einkorn (*11*). During this period, the 5th millennium, the colonization of the alluvial plain of lower Iraq was undertaken, and, according to the evidence now available, Emmer adjusted itself excellently to the artificial ecology of the irrigated land, while Einkorn did not (*11*). The same situation is encountered in Egypt (which was presumably colonized within the same general period)—namely, that Einkorn did not occur (*12, 13*).

From the nuclear mountainous arc, agriculture spread to the Mediterranean littoral and, presumably, all over Asia Minor. Boat traffic along the coast certainly accounts for many routes of migration, among which was that to Egypt. The crossing to Europe was effected quite early, and the end of the 5th millennium saw Einkorn and Emmer cultivated in the large loess plains stretching intermittently almost from the Danube delta to the mouth of the Rhine. When eventually this riverine–loess-plain belt had been saturated with population, new waves of migration set out in many directions, and during the 3rd millennium B.C. agricultural settlements cropped up in Switzerland, France, northern Italy, Spain, Britain, Central Europe north of the loess belt, and Scandinavia (Fig. 6). No doubt an early movement had already spread over the western coast lands of the Black Sea and penetrated into southern Russia. The two original cultivated wheat species adjusted themselves more or less successfully to the increasingly harder climates as farming cultures moved northwards. Einkorn reached its peak in Asia Minor, while in Britain it seems never to have got above the status of a poor relative (*14*).

The migrations were not, however, all in southerly and westerly directions. The movement that brought the alluvial plain of Mesopotamia under cultivation probably branched out and settled the high plateaus of Iran, and the early Indus valley agricultural centers were established some time in the late 3rd to early 2nd millennium B.C. There is also evidence that there was agriculture south of the Aral Sea before the middle of the 2nd millennium (*15*).

## Club Wheat and the vulgare Group

The very first time archeologically excavated and dated plant material was handed over to a botanist for identification, a wheat species was established which does not conform to the characteristics of a straight-line descendant of the two wild species, *Triticum dicoccoides* and *T. aegilopoides*. In Michelsberg culture deposits in Switzerland, Oswald Heer, in 1865, identified unmistakable remains of Club wheat (*T. compactum* s.l.) (*16*). Whereas Einkorn and its progenitor are diploid ($2 \times 7$ chromosomes) and Emmer and its progenitor are tetraploid ($4 \times 7$ chromosomes). Club wheat belongs to the Bread wheat (*vulgare*) group, which is hexaploid ($6 \times 7$ chromosomes). Modern genetical research has established experimentally that crossing of Emmer and the oriental wild grass, *Aegilops*, may produce hexaploid wheat with several features in common with the *vulgare* group (*17*). This explanation presupposes the emergence of the *vulgare* group in the Near East, but although a considerable amount of material from this part of the world has been investigated, Club wheat has not been found in early archeological contexts, while in later contexts it appears only in minor proportions in comparison with the occurrence of Emmer. On the other hand, in some of the Swiss middle-to-late 3rd-millennium finds, Club wheat was practically the only species found (*18*).

Fig. 2. Carbonized kernels (from Jarmo) similar to the wild wheats, *Triticum aegilopoides* and *T. dicoccoides*. In the upper left-hand corner is a specimen of the Emmer type kernel (×4).

A summing up of available archeological information regarding Club wheat gives the following picture: In Egypt in the predynastic (late 5th millennium B.C.) find of Merimde beni Salame (*13*) —and possibly also in Fayum (*19*)— stray grains of Club wheat were established, and the same was the case in the late 4th millennium find of el Omari (*13*). On the contrary, no *vulgare* type wheat is encountered in the large deposits of uncarbonized wheat which abound in the early and middle dynastic tombs (3rd and 2nd millennia B.C.). Poorly documented samples of Club wheat in the Egyptian Agricultural Museum suggest the recurrence of the species late in the 1st millennium B.C. (no provenance is given, and thus the dates can only be guessed) (*20*). In Iraq the earliest appearance is represented by an imprint from Jemdt Nasr of about 3000 B.C. (*11*) and a few imprints of the mid-

dle of the 3rd millennium in the Habur area in the north (*11*). The earliest proper cultivation of Club wheat in Iraq is documented by a find from eastern upper Iraq (*11*), covering a few centuries around 2000 B.C. During the 2nd millennium we find the traces of the species being cultivated in Asia Minor, Syria (*20*), and Palestine. Everywhere that Club wheat appears in the Near East it occurs together with Emmer; only at about 1000 B.C. and later (*21*) does it occur more frequently than the old-fashioned wheat. It is recorded from upper Iraq in late Assyrian times, for example, but still in small proportions (*20*).

In the light of this scattered occurrence of the species in the Near East, whence it must nevertheless be supposed to have come, the profuse and consistent occurrence of Club wheat in the 3rd millennium B.C. in Europe is, mildly speaking, confusing. In Europe, it definitely occurs in cultural contexts which must be described as being of indigenous European origin. It would seem that the spe-

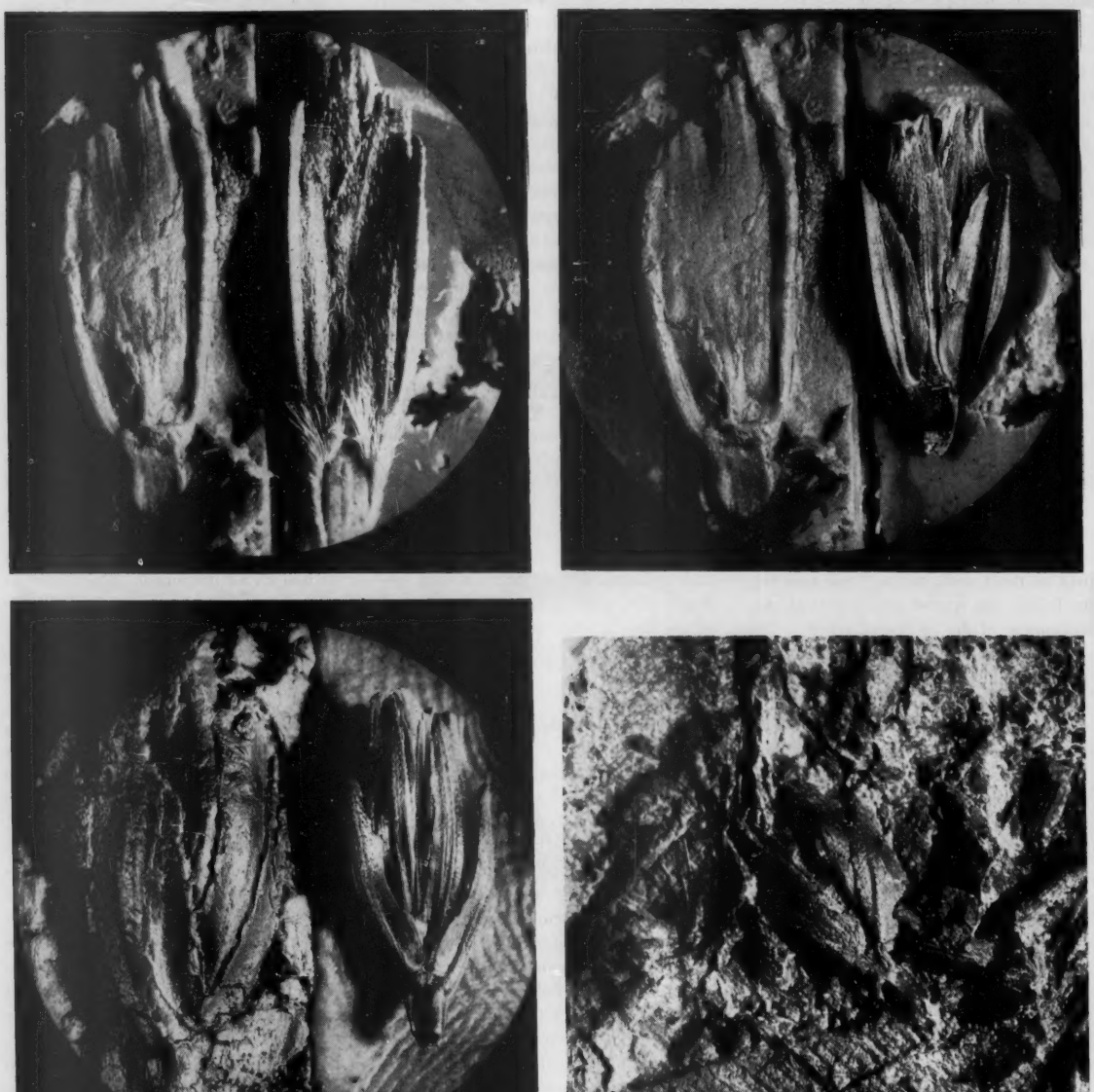

Fig. 3. (Top) Cast of Jarmo imprint of the ventral side of a *T. dicoccoides* type spikelet compared with (top left) a spikelet of the wild species and (top right) an Emmer spikelet from Fayum in Egypt, the earliest uncarbonized Emmer known (×4). Fig. 4. (Bottom left) Cast of Jarmo imprint of dorsal side of *T. dicoccoides* type spikelet compared with an Emmer spikelet from Fayum (×4). Fig. 5. (Bottom right) Imprint of Emmer spikelet from Jarmo (×4).

cies only became important when it arrived in areas with heavy summer rains, such as the Alps, but that thereafter it adapted itself to such varying conditions within the continent as those, for example, in Spain and Denmark. It is present in the earliest known deposits of cultivated plants in Switzerland (*20*), and imprints of Club wheat were found, together with those of Einkorn and Emmer, in the earliest archeological findings of agriculture in Denmark (*22*). It is suggested that it was from Switzerland that plant husbandry was introduced into Spain, where there are frequent occurrences of Club wheat.

It may well be that Club wheat emerged as a hybrid in the Near East but that the ecological circumstances did not favor its development into a definite species in its natural surroundings. It may also be that it disappeared and recurred later as a kind of freak during the early phases of agriculture, and that, brought to other climatic regions as a weed in the Einkorn-Emmer fields, it found its balance and produced a rather hardy type which flourished in mountainous environments. In my opinion, the assumption that this happened somewhere in Asia Minor would provide a workable theory for explaining the above-mentioned discrepancies. On the whole, Asia Minor is something of a terra incognita as far as paleoethnobotany is concerned; too few finds from this territory have been recovered and offered for investigation, and the area must necessarily have been most important in certain genetical developments which, on the basis of the known material, we are quite unable to understand. Ecologically heterogeneous, this landscape would without doubt have influenced the gene balance of many plants (*23*) taken through its valleys and over its mountains from the cultural melting pot of the nuclear arc.

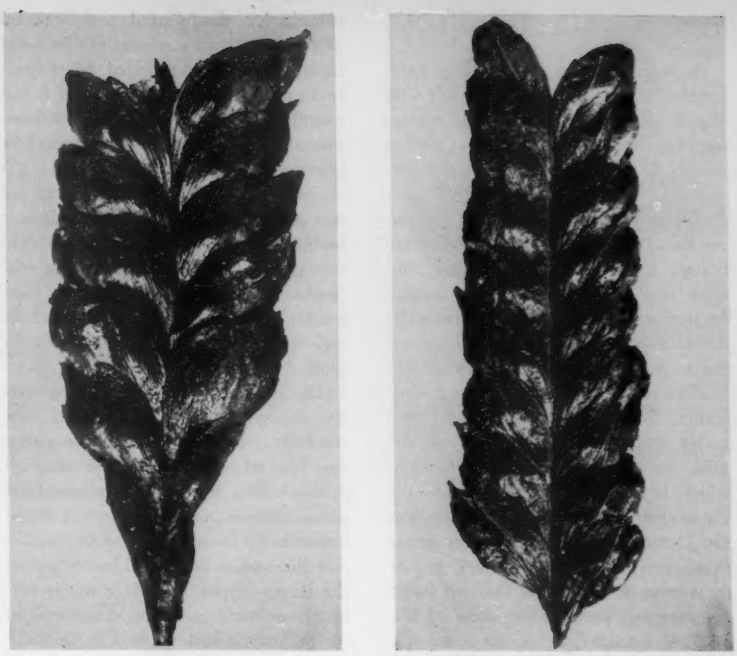

Fig. 6. Carbonized spike portions from early 2nd millennium northern Italy pile dwellings; Emmer (left) and Einkorn (right) (×4).

## Spelt and Other Later Wheats

Still another hexaploid wheat appears in the subalpine area of Europe. Spelt (*Triticum spelta*) was discovered in cultural levels of the early-middle 2nd millennium B.C. in Switzerland (*24*), southern Germany, and northern Italy (*20*). This species has the semitoughness and structural habit of Einkorn and Emmer, except that its internode adheres to the spikelet by its lower end and not, as in the two others, by the upper end. Genetics has demonstrated that a similar form may be produced by crossing Emmer and *Aegilops,* and since the peculiar articulation is found in *Aegilops* only, the explanation has a certain appeal (*17*). However, Spelt has never been found in prehistoric deposits outside Europe, and present cultivation of this species is restricted to certain Central European mountainous districts and a few other places where it is known to have been introduced in historical times by people coming from Central Europe (*25*). If it is taken for granted that the hexaploid wheats do owe their emergence to hybridization with *Aegilops,* it is perhaps not beyond the limits of possibility that a reshuffling of genes under severe mountainous conditions could have resulted in a local retrogression creating a form possessing at the same time the main structural habit of Emmer, a mode of articulation inherited from *Aegilops,* and a cytological composition that ranges it along with the *vulgare* wheats.

Scanning the Near Eastern wheat field today, we note that Emmer is no more to be found and that Club wheat is absent and Bread wheat rare and of no importance. The field is populated by wheats structurally parallel to the *vulgare* group but cytologically allied to Emmer, having 4×7 chromosomes.

We can only guess at the phylogenetic origin of the very diversiform group of these tetraploid naked wheats, which comprise Hard wheat (*T. durum*), Rivet wheat (*T. turgidum*), Polish wheat (*T. polonicum*), and several characteristic subspecies. They may have originated through mutation or through hybridization between extreme varieties of Emmer or even through interspecific crossings.

Hard wheat is the most important of the group. As opposed to the free-threshing species of the *vulgare* group, it flourishes in areas where there is a fairly modest amount of winter rain or irrigation and a completely dry ripening season. It is the wheat of the summer-dry steppe regions all over the world. The first evidence of this species occurs among the noncarbonized wheat deposits of the Ptolemaian (post-300 B.C.) period in Egypt (*26*). In the course of a few hundred years it seems to have spread all over the Near East, occupying the plains as well as the mountain tracts, at the expense of Emmer. The last stronghold of the latter is Abyssinia, where it probably was introduced with agriculture in late Egyptian dynastic times, while it was still being cultivated in Egypt itself, and where it is still being grown under the name of *Adjaz.*

## Barley

As mentioned in the opening paragraphs, all of the known ancient Old World agrarian cultures (of the regions under discussion) grew barley as well as wheat. Returning to the earliest material at our disposal, we find that barley makes up the bulk of the plant remains in the Jarmo find. The kernels are hulled, straight, and unwrinkled, and some specimens consist of the median fertile floret with one of the lateral, male florets attached (Fig. 7). The lateral florets are not sessile, as they are in modern two-row barley, but have a short pedicel. In all these features, the Jarmo barley conforms rather closely to the wild, two-row, *Hordeum spontaneum,* which is naturally distributed all over the nuclear arc and far beyond. Indeed, the Jarmo kernels are somewhat larger than those of the wild species, but of most interest is the fact that, to judge by some axis portions consisting of two or three internodes (*9*), the spike was not brittle as in the wild form but had attained at least a certain degree of toughness. This is an unambiguous indication of domestication, since the wild spike falls to pieces when dry, even if it is not completely ripe. Not one fragment was encountered to indicate the occurrence of the six-row form of barley.

In its native districts the wild barley occurs practically everywhere. I never saw a field of any crop in Kurdistan in which wild barley was not to be found growing as a weed. From man's very first attempt to till the soil, this would have been the case, and barley must have been drawn into domestication together with the first wheat, through automatic selection of the tough-axis individuals in the course of reaping. In this sense barley might already be termed a "secondary" cultivated plant (*3*). It would eventually have lost most of its prickly and very coarse character (which, even now, keeps the oriental cattle from eating the wild spikes) and have become comparable to wheat in characteristics making it suitable for human consumption.

For a long time only this species was grown in Kurdistan. It abounds in the Matarrah material, and as late as Hellenistic times (*20*) it was the principal barley of this hilly region, as it still is today.

When, in the 5th millennium B.C., agriculture was extended to the river basins of Mesopotamia and Egypt, two-row barley disappeared and was replaced by the six-row species. Two-row barley has been postulated for Fayum in Egypt (*19*), but the evidence is not unambiguous, and among some 2000 imprints of plant material from ancient lower Iraq (Mesopotamia) that I examined, there is abundant proof of the occurrence of the lax-eared, six-row barley but not one imprint of the two-row spike (*11*). Not until the 9th century A.D. does the two-row form of barley make its appearance in the archeological material from the Mesopotamian plain (*11*).

The problem of how the six-row barley emerged has been discussed ever since the last century, when the matter was first taken up for serious consideration. A long series of complicated explanations has been offered, each explanation being based upon the assumption that the earliest cultivated barley was of the six-row type (*27*). This was a perfectly reasonable assumption, since all of the prehistoric barley found in the Swiss pile dwellings and in the Egyptian tombs was undoubtedly six-rowed. At the time, there was no archeological evidence to show that these finds were from periods much later than the initial domestication of barley, and that they could not be taken as indicators of the progenitor of barley. Now we are able to show that two-row barley was cultivated some 4500 years before the first hoe turned the soil of Switzerland and about four millennia before the first pyramid was built. Furthermore, it has been shown that barley cultivation started within the distributional area of the only possible progenitor.

Also, we are now able to demonstrate that the six-row form replaces the two-row form of barley as soon as agriculture moved into the artificial ecological environment of the irrigated plain. It is a logical conclusion that this forcible change of ecology brought about the mutation that resulted in the six-row spike. That the natural qualification for the mutation actually exists is borne out by modern experiments showing the transition from two- to six-row spikes in response to radiation treatment (*28*). If this change can be produced artificially, the necessary genes must be present in the species; genes cannot be created.

Since the early 7th millennium B.C., endless interbreeding has produced varieties of barley of almost every conceivable morphological composition, adapted to the most varying climatic and ecological conditions. For example, there are two-row and six-row spikes with hulled or naked kernels of many different colors, some as dense as Club wheat, some as lax as Spelt, having florets with exaggerated development of the glumes, or with a trifurcate appendage in place of the awn; even freak spikes with a branching axis exist. *Hordeum spontaneum* grows only in the area indicated in Fig. 1 and in western North Africa, while barley is cultivated almost from the Equator to the North Cape, and from Japan to Ireland, as well as in huge areas in the two Americas and in Australia, and at elevations from 1100 feet below sea level, at the Dead Sea, to some 12,000 feet above the sea in the Himalayas. The naked forms did not emerge along the hilly flanks of the river basins of southwestern Asia and were never grown there; they appear at such widely dispersed places that it must be taken for granted that they have appeared independently in response to ecological pressure. We find them cultivated today in Abyssinia, central Asia, and the Far East, and in prehistoric finds the naked forms appear in Turkey (*20*) and in western and northern Europe and Scandinavia, but not in Egypt (*29*), the nuclear arc of southwestern Asia, Italy, or Switzerland. The same applies for the dense-eared form of six-row barley. It does not appear in the Mesopotamian plain, but there is evidence of it in the Fayum find in Egypt. The earliest occurrence of dense-eared, six-row barley is probably the Mersin find (*30*), but unfortunately this find is not precisely stratified, although it may be considered to belong to a level not later than the Hassuna period (about 5750 B.C.). Whether it emerged directly from the cultivated two-row form or by way of the six-row lax-eared form is not clear, but certain anatomical features support the former alternative.

Here again we need evidence from the mountainous parts of Asia Minor. In Europe, dense-eared barley is characteristic of the subalpine area, while it seems to be lacking in the plains and in the northern and western coast lands (*14, 31*). To judge by its present-day distribution, dense-eared barley might be described as a mountain form.

This is, very briefly, the story of plant domestication compiled on the basis of first-hand study of the actual remains of the ancient plants of a large portion of the Old World. But it is by no means the whole story. Undoubtedly, the possession of domesticated wheat and barley were the principal factors in the

Fig. 7. Carbonized triplets of two-row barley from Jarmo (×4).

immense expansive power of the first agrarian cultures in the Near East and later in Europe, but many other plants were forced into subservience to feed the increasing millions of mankind.

## Other Food Plants

The domestication of weed grasses took place at later periods and far from the centers of natural distribution of these grasses (*3*). Thus, rye and oats were introduced into Europe as weeds in the wheat fields—rye probably from western central Asia and oats from the Near East or Eastern Europe. Oats attained the status of a crop plant during the 1st millennium B.C., and rye was brought into secondary domestication in Central Europe shortly before the birth of Christ. Broomcorn millet appears for the first time about 3000 B.C. in Jemdt Nasr in Mesopotamia (*11*); although it does not seem ever to have achieved any great importance in the Near East, it rose to a high level of importance in the Far East, while in Europe it was widely cultivated about 2000 B.C. (*32*). The progenitor of broomcorn millet is not known, whereas another useful member of the genus, Italian millet, is considered to be the straight-line descendant of the wild green millet, *Setaria viridis*.

The pea family also added considerably to the stock of domesticated plants. In Jarmo we already find evidence of the use of field pea (Fig. 8), lentil, and blue vetchling for food, although we cannot claim that they were deliberately cultivated at that time. Fourth-millennium, B.C., finds in Egypt demonstrate the presence of lentil, and Swiss deposits of the 3rd millennium contain pea and blue vetchling, while lentil is encountered in several localities in Hungary. The horse bean appears around the Mediterranean during the 3rd to 2nd millennium B.C., and later it spread to most of Europe, arriving in Britain in the late 1st millennium B.C. Chick-pea, which today is a much-cultivated plant in southern Europe and western and central Asia, occurs in Palestinian finds of the 4th millennium or possibly even earlier (*20, 33*).

All the plants discussed above are useful principally because of their content of starch, but vegetable oil also has always been highly valued as human food. From the Jarmo find and other evidence it appears that oil-bearing food was easily secured by gathering the fruit of wild trees—acorns and pistachios in the Jarma area and, in other regions, hazelnuts, acorns, and olives. Moreover, the early agriculturalist found the wild species of the flax genus, *Linum bienne*, which he domesticated. As early as the 5th millennium B.C. the definite and highly useful species, *L. usitatissimum*, was grown in the foothills of the Kurdish mountains (*11, 34*) as well as on the alluvial plains of Mesopotamia (*11, 35*) and Egypt (*19*).

While in the foothills the seeds were rather small, the linseeds from the plains attained an increasingly larger volume as time passed. It seems as if this development was associated with irrigation. The plant also spread to Europe, and it is found in habitation sites in Switzerland of the early 3rd millennium B.C. Here, however, the seeds were of the same size as those grown in the foothills of Kurdistan some two millennia earlier (*36*). Furthermore, the existence of Neolithic flax in Spain, Holland, and England has been established.

Since we find the earliest traces of cultivated flax in the same general region in which wheat and barley were domesticated, at a period much earlier than that of the Swiss pile dwellings, and since the wild flax, *L. bienne*, is abundantly distributed in this same region as a winter annual (like the Neolithic Swiss variety), it is reasonable to conclude that the Swiss flax was part of the agricultural assemblage introduced, presumably by way of the Danube basin, from the Near Eastern nuclear area.

This view is not new. It has already been presented by Heer, De Candolle, and Könicke. Neuweiler's concept, that the pile-dwelling flax was derived from the native Swiss wild species, *L. austriacum*, can be shown anatomically to be untenable. The recent archeological findings in Iraq form the final link in the chain of evidence (*37*).

The wine grape, which is naturally distributed in mountainous forests in certain parts of the Near East, was cultivated in the 4th millennium B.C. or earlier. Traces of this plant are dispersed and rare, and it is too early as yet to tell its story (*20, 38*). Olive and date also are encountered in Palestinian (*20*) and Egyptian finds, respectively (*39*), of the 4th millennium B.C., but both species may be supposed to have been exploited and even domesticated at an earlier time. Although apple, pear, cherry, fig, olive, and wine grape were naturally distributed in various parts of Europe, we have no evidence of their cultivation west of Greece until the 1st millennium B.C., and particularly in Roman times. Indeed their fruits were exploited from very early times, but it seems as though the idea of orchard husbandry and viticulture (*40*) was introduced from the East, together with domesticated varieties of the species.

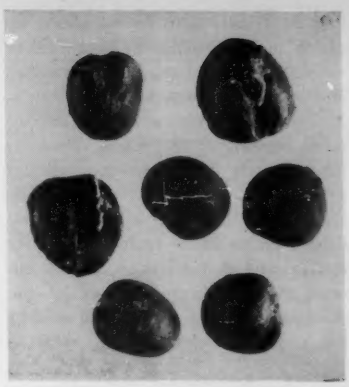

Fig. 8. Carbonized seeds of field pea from Jarmo (×4).

Even from this brief sketch it will be clear that the actual and well-dated plant remains of the prehistoric and early historic past—be they in the form of mummified or carbonized material or imprints in baked clay—are of the greatest interest to both the cultural and the natural historian, and thus to science generally. The cultural historian seeks to know the economic background for the achievements and migrations he is able to visualize through his excavations, and in its ultimate definition, economy means food. The botanist is anxious to know whence the cultivated plants came, how long a time it took them to develop their present form and the physiological qualities which differentiate them from the wild species, how this development came about, and, not least, from which wild plants or combinations of plants the domesticated forms descended. By

keeping a meticulous record of stratification, modern archeology has means by which to tell the date of plant material, and by specialization the botanist will, in the long run, learn to identify the battered remains of the plants. Thus, by joining hands, the two sciences establish a third, paleoethnobotany, which endeavors to help delineate man's victories and defeats in his battle against nature for survival and multiplication, and to unravel the complicated history of the plants upon which even modern civilization is ultimately dependent.

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2. J. Iversen, *Danmarks Geol. Undersøgelse II* (1941), p. 66.
3. Primary domestication involves specific and conscious attention to a wild plant in its natural habitat; secondary domestication is the segregation, for intentional cultivation, of a weed growing in cultivated soil which already unintentionally has been subjected to a process of selection through being reaped along with the intended crop. In the cases of rye and oats, this segregation occurred far from their centers of natural distribution; by comparison, barley is secondary only insofar as human intention is concerned, not in respect to habitat.
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23. See, for example, J. R. Harlan, *Sci. Monthly* 72, 87 (1951) and *Am. Naturalist* 85, 97 (1951), on the great diversity and rapid evolution of plants in Turkey.
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27. I except here, of course, the concept of F. Koernicke that the wild *H. spontaneum* was the progenitor of all cultivated barley, a proposal which has been consistently rejected. See the brief survey of theories regarding the derivation of barley in E. Aberg, *Symbolae Botan. Upsaliensis* 4 (1940).
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29. Many reports on Egyptian grain postulate the occurrence of naked barley in prehistoric and dynastic deposits. No documentation has ever been published, and according to my experience, which includes examination of many grain finds, the postulate is unfounded.
30. I examined a sample of the barley from Mersin at Reading University and found it to be a small-grained hulled form of *H. hexastichum*. Its date, as pronounced by V. Gordon Childe, who brought the sample back from Mersin, was "well into the fourth millennium, probably earlier."
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# Age of Sex-Determining Mechanisms in Vertebrates

## Distribution of differentiation patterns indicates the evolutionary path of genes and chromosomes.


Emil Witschi


In vertebrates hermaphrodism may occur as an exceptional condition. However, as a rule the production of eggs and sperm is separately managed by female and male individuals. In most species the basic sex ratio—that is, the proportion of males and females unaffected by differential mortality or selection—is close to equality. It has been shown that this balance is maintained by a self-perpetuating genetic mechanism. One of the sexes produces two types of germ cells—female-determining and male-determining ones; this is the digametic sex. The two types of gametes are produced in equal numbers because they result from a difference in genic content between partners of a single pair of chromosomes, the sex chromosomes or heterochromosomes. Geneticists designate the condition of somatic cells and of primary gonia that have uneven pairs of chromosomes or genes (hereditary factors) as heterozygoty. *Hence, the digametic sex is also heterozygous.* It produces two types of gametes in equal numbers, because the unequal chromosome pairs become mechanically segregated during a maturation division, each gamete receiving one or the other of the partners. The other sex produces only one type of gamete. It is unigametic, because the sex-chromosome pair of its gonia consists of even partners, which are the equal of one only of the heterochromosomes of the digametic sex.

To understand this article it is important to realize that this genetic and chromosomal mechanism of sex determination occurs in two patterns, depending on which sex is the heterozygous and digametic one. If, as in man (or the opossum) this is the male, then one designates the partners of the hetero-


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chromosomal pair as X and Y, and it is understood that X stands for the chromosome type which appears as an even pair (XX) in the female. Hence, the total formula of this pattern is written as XX-XY, symbols for all the other chromosomes (autosomes) being omitted. On the other hand, in all species that have digametic females and unigametic males, the pattern formula is ZW-ZZ, the female being heterozygous (ZW) and the male homozygous (ZZ).

## Genes and Chromosomes

The peculiar distribution, among vertebrates, of the genotypes XX-XY and ZW-ZZ raises the question whether initially mere chance or specific physiologic conditions decide the alternative of evolution toward male or female digamety. Some fishes (for example *Xiphophorus*) apparently have not yet established a genetic sex-determining mechanism (1). Inasmuch as microscopically identifiable sex chromosomes are unknown in the entire superclass, the Pisces represent, altogether, a primitive and ancient condition. Nevertheless, the existence of competent sex chromosomes is revealed by the sex-linked inheritance of color marks and of other somatic characteristics in several species. The Japanese rice fish *Ozyzias latipes*, bred after sex reversal, furnishes direct evidence of male heterozygoty in a sex-determining factor (2). It is significant that in some river systems of Mexico and Honduras, *Platypoecilus maculatus* is XX-XY type and in other river systems, of ZW-ZZ type. Apparently each pattern was acquired after the rivers had gained separate outlets to the sea, an estimated 300,000 years ago (3).

Genetic differentiation is also rather primitive in the Amphibia. Morphologically identifiable sex chromosomes are reported only for males of true frogs (4) and tree frogs (5). They are not distinctly dimorphic but show characteristic peculiarities of incomplete conjugation not observed in spermatocytes of sex-reversed females. Breeding experiments confirm that frog males are of -XY type. The other anurans (toads) and all the urodeles that were genetically tested follow the ZW-ZZ pattern of sex inheritance; sex chromosomes are not morphologically recognizable.

All genetically and cytologically analyzed mammals have proved to be of the XX-XY type. Visibly differentiated X and Y chromosomes have been reported for males of about 240 species. Conversely, reptiles (nine species) and birds (37 species) are uniformly of the ZW-ZZ type (6). It is usually assumed that in the course of evolution the W chromosomes have disappeared, so that sauropsid females actually would be of ZO constitution, but so far, the absence of the W chromosome has been demonstrated unequivocally only for the domestic chicken (7). The chromosomal and genetic uniformity in higher vertebrate classes indicates that all sauropsids are descended from a small stock of ancestors that had already assumed the ZW-ZZ type, and all mammals, from a corresponding group that had acquired the XX-XY type. Since fossils do not reveal anything about chromosomes and genetic mechanisms of sex determination, the state of evolution attained 250 million years ago by Devonian lungfishes, ancestors of all tetrapods, remains conjectural. Nevertheless, the universality of the -ZW type among sauropsids suggests that it originated very early, probably in amphibian or even piscine ancestors. The possibility presents itself that, genealogically, salamanders (ZW) thus may be rooted close to the sauropsids, and frogs (XY), near the mammalian evolutionary lines. This possibility is discussed below.

Table 1. Categories of genetic and physiologic types of sex determination in vertebrates.

| Species or taxonomic group | Genetic pattern | Physiologic reaction patterns | | | |
|---|---|---|---|---|---|
| | | 1. Hormonal sex reversal* | 2. Inductive sex reversal* | 3. Self-differentiation of secondary sex characters | 4. Reaction of oviducts to testosterone |
| *Oryzias* (teleost) | XX-XY | F→M; M→F | | | |
| *Rana* | XX-XY | F→M; m→f | F→M | | Neg. |
| *Xenopus* | ZW-ZZ | M→F | F→M | | Pos. |
| *Bufo* | ZW-ZZ | m→f | M→F | | |
| *Pleurodeles* | ZW-ZZ | M→F | | | |
| *Ambystoma* | ZW-ZZ | M→F | F→M; m→f | Ambisexual | Pos. |
| Reptiles | ZW-ZZ | m→f | F→M | Ambisexual | Pos. |
| Birds | ZW-ZZ | m→f | F→M | Ambisexual and male | Pos. |
| Opossum | XX-XY | m→f | | | Pos. |
| Eutheria, *Homo* | XX-XY | f→m | F→M | Female | Neg. |

* M→F, complete reversal of genetic male into female; F→M, complete reversal of genetic female into male; m→f and f→m, incomplete reversals.

## Physiologic Patterns

Not so sharply defined and less generally known are the physiologic types of sex determination in vertebrates. The balance of genic sex factors directs the embryonic differentiation of gonads and secondary sex characters by chain reactions, which, however, may be modified or entirely switched about by the interference of physiologic, chemical, and physical factors. It is possible to arrange some of them in four categories (Table 1). Remarkably often they parallel the genetic sex types (8).

1) Exposure of embryos to steroid sex hormones during, and sometimes also after, primary sex differentiation may lead to partial or complete gonadal sex reversal. In the genetic XX-XY type, particularly in frogs and Eutheria, masculinization of genetic females is often successful, while in the ZW-ZZ type, feminization of genetic males is the usual reaction. Feminization of *Pleurodeles* and *Xenopus* after estradiol treatment is so complete that functional females of male genotype can be produced at will and bred with nonreversed males. Two notable exceptions to the rule that steroid hormones reverse preferably the homozygous sex are presented by the opossum and the small teleost *Oryzias*. Both belong to the -XY type. In the opossum, Burns (9) obtained considerable cortical development in estrogen-treated males, and in *Oryzias*, Yamamoto induced complete transformation in both directions, using either estrogens or androgens (2). The case of *Oryzias*, though very interesting, is not discussed here because the embryologic process of gonadal differentiation in *Oryzias* is very different from that in higher vertebrates.

2) Inductive sex reversal has been obtained by natural or experimental parabiosis, and by teratologic or surgical reduction of the genetically epistatic gonadal element (medulla in the case of

Fig. 1. Spermatogonial metaphase; X and Y chromosomes in the center. Fig. 2. Metaphase of dividing somatic cell of a female animal; two X chromosomes in lower central region. Fig. 3. Ovogonial metaphase with two X chromosomes in center. All figures show the total number of 22 chromosomes, characteristic for the opossum; Figs. 1 and 2 are from squash preparations; Fig. 3 is from a section of the ovary. [All × 1500.]

*Bufo,* cortex in the female bird). Some completely sex-reversed frogs, toads, hens, and human individuals (pseudomales, typically exhibiting the Klinefelter syndrome) produce mature germ cells—eggs or sperms—of the assumed sex. It will be noted that in ZW- types, the direction of this transformation usually is the reverse of that produced by hormone treatments.

3) Secondary sex characters arise from primordia that are identical in both sexes and in early castrates. The later development of a male or a female organization ordinarily corresponds to the presence of testes or of ovaries, respectively. However, in mammals the female type of gonaducts and external genitalia is also assumed in the absence of gonads, by self-differentiation, regardless of chromosomal constitution (*10*). In castrated amphibians (those most thoroughly investigated were newts), a neutral, ambisexual condition of the gonaducts is maintained (*11*), and in agonadic ducks, the phallic organ and the syrinx spontaneously acquire the male type during the later part of the incubation period. The gonaducts of all early castrates in birds and reptiles maintain an ambisexual condition, with persistence of paired oviducts and mesonephric ducts (*12*). In summary, if self-differentiation of secondary sex characters continues into the phase of sexual dimorphism, it follows the pattern of the homozygous genetic type.

4) Oviducts, in response to treatment with testosterone, become greatly enlarged in *Xenopus,* salamanders, reptiles, and birds, while in frogs (*13*) and Eutheria their growth is only slightly stimulated or is reversed. The refractoriness common to frogs and Eutheria, supports other evidence which suggests relatedness of these taxonomically distant groups. Exceptional among mammals is the opossum, whose oviducts show a strong positive reaction to testosterone treatments (*14*), resembling the response in reptiles (*15*).

## The Case of the Opossum

Since there are striking similarities in hormonal reactions between the opossum and the sauropsids, it seemed desirable, in order to assert the reliability of the evidence in support of male heterozygoty for these vertebrates, to reinvestigate the chromosomal condition by modern methods. The study made with the assistance of K. Mikamo confirms the occurrence of a small XY pair of chromosomes in the male (*16*). In spermatogonial divisions, it is usually located in the center of the metaphase plate (Fig. 1). The same position is held by the XX pair in ovogonial and in female somatic mitoses (Figs. 2 and 3).

## Discussion and Conclusions

Although it is quite singular and has still not been completely investigated, the case of the opossum proves that physiologic reaction patterns do not issue from, and are not determined by, the genic sex type. The existing correlations are more readily explained on a genealogic basis, according to which the peculiar reaction of the opossum appears to be an old inheritance from a premammalian epoch, when genic sex patterns had not yet evolved. The further inference that the XX-XY pattern originated after the Cretaceous mammals separated from primitive reptiles, but before they branched into marsupials and insectivores, is plausible even though not strictly compelling. (In separate groups the same genetic type may become initiated merely by chance.) In addition to the American opossum, about 30 Australian marsupials are known to have heterochromosomes in the male sex. In view of the early separation of the two faunas, this finding adds new support to the contention that the XX-XY pattern was already established at the inception of mammalian evolution.

The genetic and physiologic similarity of ranid amphibians and Eutheria poses a difficult problem. In some frogs the difference between the sex-determining values of the X and Y chromosomes is very small. This condition establishes a formal proximity to the origin of male digamety (*17*); however, it does not necessarily imply that genetic sex determination in such species is of recent date. For some obscure reason, in fishes and amphibians the sex genes have changed more slowly than in sauropsids and mammals. The same circumstances that kept the lower vertebrates morphologically at a Paleozoic level apparently have also retarded their sexual evolution. In some taxonomic groups protracted periods of arrest must have occurred. Evidence of slow changes in the Y chromosomes of frogs during the postglacial epoch (*18*) favors the view that mutational frequency and evolution depend on particular environmental influences.

For obvious reasons it is difficult to reconstruct the history of the types of physiologic reaction. The sauropsid and salamander type, characterizing also the lower mammals (opossum) and anurans (toads), with its low grade of specificity in hormonal reactions, seems to be the more primitive and hence the more ancient of the two. The eutherian and frog type, with its more discriminating reactions and restricted taxonomic distribution, probably evolved more recently.

In conclusion, the fact that the parallelism between genetic and physiologic patterns of sex determination is not without notable exceptions serves to disprove the supposition that causal relationships exist between genetic digamety and hormonal reaction types (*19*). On the other hand, the distribution of all patterns can be understood on the basis of genealogic relationships. The finding of an exceptional, mixed

type in the opossum supports the assumption that the XX-XY type originated before the separation of marsupials and insectivores and before the evolution of the eutherian reaction pattern. The separation of the anuran amphibians into -XY frogs and ZW- toads makes it clear that here the genetic mechanisms of sex differentiation evolved after the anurans (Salientia) had made their appearance (Jurassic period) but before separation into the families of today. When the available evidence is pieced together, it appears that genic sex determination in tetrapod vertebrates originated during the Jurassic period, an estimated 150 million years ago. Since evolution proceeded more slowly in some groups than in others, continued studies in comparative cytogenetics can be expected to furnish a complete recapitulation of the successive steps in the evolution of sex-determining genes and of sex chromosomes (*20*).


## Summary

Certain characteristic patterns of physiologic sex determination are not causally linked with types of genic and chromosomal constitution (XX-XY or ZW-ZZ). The observed widespread but not universal parallelism in the distribution of genetic and physiologic patterns among vertebrate groups expresses genealogic relationship. On the basis of this interpretation one may estimate the approximate evolutionary age of the mechanism of genetic sex determination. It is concluded that in all tetrapod vertebrates these mechanisms originated during the Jurassic period. Environmental conditions seem to affect the progress of this evolution.


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# News of Science

## International Oceanographic Congress To Meet at United Nations Headquarters

The world's leading oceanographers, perhaps 600 strong, will meet in New York at the end of August for their first international congress. The scientists, representing more than 35 countries, will participate in a broad study of the oceans—of their histories, their inhabitants, their boundaries and basins, and their deep areas. The congress, which will be the first large scientific meeting ever held in the United Nations headquarters, will be in session from 31 August to 12 September. Seven oceanographic vessels, including the Soviet Union's new *Mikhail Lomonosov*, are expected to be on display at New York piers during the 13-day congress.

Three scientific organizations—the AAAS, UNESCO's International Advisory Committee on Marine Sciences, and the Special Committee, on Oceanic Research of the International Council of Scientific Unions—are sponsoring the meeting. Financial support is being provided by 21 governmental and private agencies.

A number of factors lie behind the decision to hold the oceanographic congress. The primary one was the success of the AAAS's 1955 Arid Lands Conference, held at Albuquerque, N.M. This meeting, which was attended by 525 people, showed the value of international gatherings of experts from scientific fields in which, because of the interdisciplinary nature of the field, congresses are seldom or never held. Reports indicated that conservation groups throughout the world found new support for their programs as a result of the arid lands meeting. Because no such congress had been held in oceanography, the officers of the AAAS and the other sponsoring organizations planned the forthcoming meetings.

There have been a number of recent indications of a growth of interest in oceanography. One was the publication early this year of a 12-part report by the committee on oceanography of the National Academy of Sciences–National Research Council. This report, which represented the work of the committee since its establishment in 1957, assessed the current state of oceanography in America and outlined a program for the future. The picture presented was not encouraging; less is known, the committee reported, about the ocean floor than is known about the near side of the moon.

Hearings in the U.S. Congress were held to study the 10-year program called for in the report. This resulted in an increase in interest on the part of the scientific community and the public. Recently *Time* devoted its cover story and six pages of photographs to oceanography and to Columbus Iselin, director of the Woods Hole Oceanographic Institution.

### Papers and Events

During the morning sessions of the conference, some 30 papers will be offered by leading oceanographers. Papers to be read on the opening day are "Shape and structure of ocean basins," by Maurice Ewing of the Lamont Geological Observatory; "Forces and processes at work in ocean basins," by Sir Edward Bullard of Cambridge University; and "Stratigraphy of the deep sea," by Edwin Hamilton of the U.S. Navy Electronics Laboratory, San Diego, Calif.

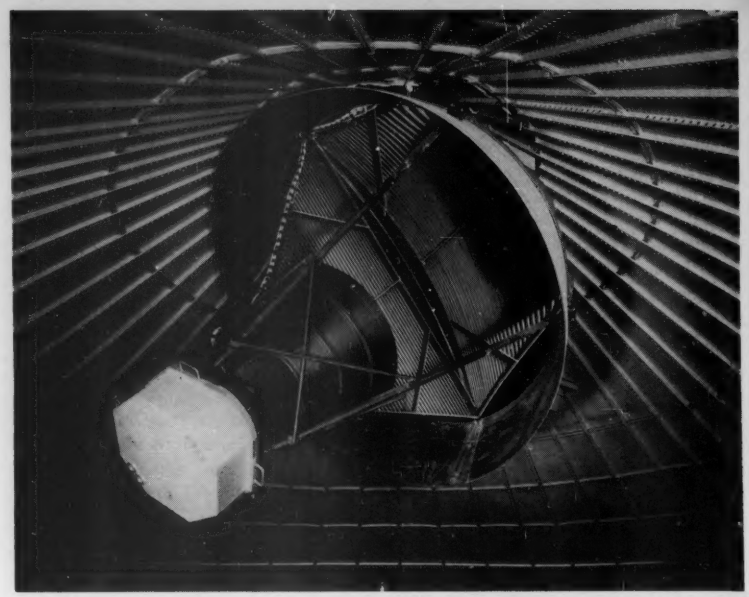
The afternoon sessions will be taken up with seminars, at which shorter papers will be read and discussed. Approximately 460 of these brief addresses, of which many will be read by title only, are listed in the program. Some of the titles for the first day's seminars are "Seismic waves from nuclear explosions and the structure under the Western Pacific," by D. S. Carder of the U.S. Coast and Geodetic Survey; "Pacific Oceanic crust," by R. W. Raitt and G. G. Shor, Jr., of the Scripps Institution of Oceanography; and "The exploration of an interplain deep sea channel," by A. S. Laughton of Great Britain's National Institute of Oceanography.

Among the tours and special events which are planned are a cocktail party at the American Museum of Natural History, a visit to the New York Zoological Park, a trip to the Bureau of Commercial Fisheries' Biological Laboratory in Milford, Conn., and various dinners. In addition, it is expected that the United Nations Building will be open for inspection. An information center will be located in the Hotel Commodore, 42nd St. and Lexington Ave., in the South Room, off the lobby. The center, which will also serve as a lounge for all registrants and guests, will be operated by the Woods Hole Oceanographic Institution.

## U.S., International Atomic Energy Units Sign Contract

The first research contract between the U.S. Atomic Energy Commission and the International Atomic Energy Agency was signed recently. The contract makes $20,000 available to the IAEA for research on the production of calcium-47, an important radioisotope now in short supply. This is the first contract negotiated under the U.S. offer, made at the second IAEA General Conference, held in Vienna last October, to explore with the Agency a program in which specific research projects could be assigned by the United States to the Agency. The latter would then make contracts with existing nuclear centers and universities throughout the world. As explained to the Vienna conference by AEC chairman John A. McCone, then also chairman of the U.S. delegation, the objective is "to bring the wealth of scientific and technical competence throughout the world to bear on the advancement of peaceful uses of nuclear energy."

Calcium-47 is of great potential significance in biological and medical research. It can be used in clinical research and for limited routine diagnosis of disease. It can be used to study normal calcium metabolism, thus opening the way to investigations of malfunctions in calcium metabolism which occur in certain endocrine-gland and skeletal disorders. It is also expected to be of use in localizing the spread of bone tumors before they can be detected by conventional means such as x-rays. The contract calls for the IAEA to use the $20,000 in a research effort to develop a cheaper method of enriching calcium-46. The funds were allocated from the Atomic Energy Commission's Division of Biology and Medicine, and the contract will be administered by the commission's New York Operations Office.



Radiometer used by the U.S. Navy to measure the thermal power radiated by ocean surfaces. The device is attached to the underside of Naval airships.

## Airborne Radiometer

The Naval Research Laboratory, according to a report in *Naval Research Reviews,* has been engaged for the past few years in a study of the physical properties of the oceans as revealed by measurements of radiant energy from their surfaces, with particular emphasis on the optics of the atmosphere and sea. One of the tools developed for this study is a massive radiometer designed to be flown in big Navy airships, at an altitude of 1000 feet. The instrument measures and records continuously the thermal power radiated by the sea, plus that small portion which orginates in the sky and is reflected from the sea.

Radiometers of two different configurations are employed. The first utilizes a single receiver. It consists of a parabolic mirror 100 inches in diameter, with a focal length of 70 inches. The second radiometer has a differential configuration. The 100-inch mirror is split along a diameter and is opened outward 15 degrees, thereby forming two independent collecting areas.

By means of the radiometers, much has been learned about the radiometric properties of the sea and their relationship to the state of the sea. For example, the radiometers have revealed that man-made oil slicks alter the wave structure enough to effectively improve the reflectivity of the surface where the slicks occur, thereby making those surfaces reflect more sky radiation. This means that the slicks are colder, in general, than the surrounding water. The radiometer has also shown that isolated clouds casting their shadows on the water during the day produce colder areas, while clouds at night produce warmer areas. The opacity of the clouds acts as a shield against incoming solar radiation during the day and, similarly, against reradiation to the cold sky at night. When these clouds drift on, they leave detectable warmer or colder patches on the water.

Cat's paws (water sufaces which have been ruffled by the wind) differ radio-

metrically from the surrounding sea. The difference is determined by many variables, such as cloud cover, time of day, and absolute humidity. Many local ocean currents may be identified by radiometric qualities that differ slightly from those of the surrounding sea. For example, it is easy to plot the edges of the Gulf Stream. Under some conditions it is possible also to follow the flow of rivers out into the ocean.

## AAAS Theobald Smith Award

The Theobald Smith Award of $1000 and a bronze medal, which has been given yearly since 1937 (except for a lapse during the war years) by Eli Lilly and Company of Indianapolis, under the auspices of the American Association for the Advancement of Science, will be presented at the association's 126th meeting in Chicago, Ill., 26–31 December. Travel expenses will be paid by the donors to enable the recipient to receive the award in person.

Nominations are now being requested for the award. They may be made by fellows of the AAAS and should be sent to the secretary of the Section of Medical Sciences, Dr. Allan D. Bass, Department of Pharmacology, Vanderbilt University School of Medicine, Nashville 5, Tenn.

The prize is given for "demonstrated research in the field of the medical sciences, taking into consideration independence of thought and originality." Any investigator who was less than 35 years of age on 1 January 1959 and is a citizen of the United States is eligible. The research is not to be judged in comparison with the work of more mature and experienced investigators.

*Nominations must be received before 1 September.* All nominations should be accompanied by six copies of a two-page summary in the form of a letter of nomination which describes in detail the importance of the candidate's work; six copies of any manuscripts ready for publication; six reprints of each of the candidate's more important published articles; and six copies of a brief biographical sketch of the candidate.

The committee of judges consists of Wallace O. Fenn, University of Rochester School of Medicine and Dentistry; Arthur Kornberg, Stanford University School of Medicine; John J. Bittner, University of Minnesota Medical School; and Stanhope Bayne-Jones, technical director, Research Office of the Surgeon General, U.S. Department of the Army, Washington, D.C. Nathan W. Shock, Baltimore City Hospitals, chairman of AAAS section N (Medical Sciences), is chairman, ex officio; Dr. Bass will serve as ex officio secretary.

## Antarctic Laboratory

The recently completed U.S. Antarctic Biological Research Laboratory has begun full operation. The laboratory, built and equipped through a National Science Foundation grant of $82,000 made to the Arctic Institute of North America, is located at the Naval Air Facility on Ross Island, McMurdo Sound. Work currently being performed by two biologists spending the winter there includes research in entomology, microbiology, and marine taxonomy. The laboratory and research work are part of the United States Antarctic Research Program arranged by the National Science Foundation in consultation with the NAS-NRC Committee of Polar Research.

An extensive survey of land invertebrates is now being conducted by Madison E. Pryor of the University of Tennessee, station scientific leader. Objectives of the research are to determine the kinds and numbers of invertebrates in the region, the relationships between plants and animals, and methods by which invertebrates have adapted to extremes of climate. Under study as part of a Stanford University project are the population characteristics of antarctic fishes, their growth rates and metabolic rates, and the identity, distribution, abundance, and ecology of inshore marine invertebrates. The project is under the direction of Donald E. Wohlschlag of Stanford, who was in the antarctic last summer.

Present plans call for extensive field work to be performed at the laboratory during the coming austral summer. The program will be expanded to include additional work in pathology and microbiology.

## Machine Translation of Russian

Experiments in machine translation which the National Bureau of Standards has been performing for the Army Office of Ordnance Research now point the way to practical production of English text from Russian technical literature, according to the bureau's news bulletin. In a translation scheme recently developed, an electronic computer is instructed to weld together the English equivalents of the Russian word in a given text to make a meaningful reproduction of the original sentence. Studies have been carried out on a high-speed electronic computer by a member of the mathematical staff.

The machine is first instructed to change the words of a Russian sentence into a highly condensed form for matching in the glossary. The machine is then told to recognize the syntactical relations between the words. After this, it puts together the English words into a meaningful sentence. Expected improvements and short cuts in the programming, and use of the advanced computers now under construction, may reduce the expense to a point where machine translation will cost no more than employing a human translator.

## Combined Curriculum

Columbia University and Wittenberg College, Springfield, Ohio, will offer a 5-year combined program in liberal arts and engineering, officials of the two schools announced recently. The plan will enable students to earn both the bachelor of arts and the bachelor of science degrees in a 5-year period. Under the program the student will study for 3 years at Wittenberg and for 2 years and a summer at Columbia's School of Engineering. After completing the graduation requirements of each institution, the student will receive a bachelor of arts degree from Wittenberg and a bachelor of science degree in a specialized engineering field from Columbia.

Columbia has arrangements with 41 other American colleges for such a combined curriculum.

## Zero Gradient Synchrotron

Construction of a 12.5 billion electron volt particle accelerator, the Zero Gradient Synchrotron, has begun at the Argonne National Laboratory near Lemont, Ill. The facility is operated by the University of Chicago, under contract with the Atomic Energy Commission. Officials from Congress, the Atomic Energy Commission, and Argonne National Laboratory participated in the groundbreaking ceremony. Construction of the synchrotron, at an estimated cost of $29 million, is expected to be completed early in 1962.

Three buildings will be constructed for study purposes at different sites

around the accelerator ring. The site will also include an equipment structure located inside the ring, a laboratory and office building, and a shop and assembly structure. A tower will be provided for cooling the water necessary for operation of the giant magnet.

## Image Tube

An image tube, a device which may make the new 120-inch telescope at the University of California's Lick Observatory as powerful as an even larger instrument, will be tested at the observatory in September. This was disclosed during recent dedication ceremonies for the telescope, second largest in the world, at Mount Hamilton, California. The image tube, still in the early developmental stages, is a device designed to multiply the power of optical telescopes. Speakers at the dedication were Clark Kerr, president of the University of California; Donald H. McLaughlin, chairman of the regents of the university; and A. E. Whitford, director of the Lick Observatory.

According to Whitford, major studies will be made of distant galaxies that can be studied only with the 120-inch telescope and the 200-inch telescope at Palomar, and of young stars still in their formative stage. These studies may yield new understanding of the evolution of the universe.

Through instruments and ingenuity, Whitford said, it may be possible to multiply the basic power of the telescope and "bring into view objects never yet recognized."

## Soviet Patents and Inventions

For the first time since 1940, the Soviet Union is permitting export of copies of a bulletin listing patent specifications and applications. The action was authorized by the Committee on Inventions and Discoveries of the U.S.S.R. Council of Ministers. The bulletin, which is published 24 times a year, gives information on the approximately 10,000 patents issued each year. It also includes descriptions of inventions of previous years. Until recently, dissemination of such data was prohibited by a specific statute concerning inventions and technical improvements. Pergamon Press will publish a monthly translation of the bulletin under the title *U.S.S.R. Patents and Inventions.*

## News Briefs

A controlled-environment laboratory for studying the effects of environment on plants and animals will be constructed at the University of Wisconsin with the assistance of a $1,500,000 grant from the National Science Foundation. In this combined plant-study and animal-study facility, botanists and zoologists will be able to consider common scientific problems and their interaction. Present plans call for 30 artificially lit environmental growth rooms and for both conventional and controlled-temperature greenhouses in the plant-research section. There will be rooms for studying the effects of dew, rain, high air velocity, and especially low temperature coupled with high light intensity. Areas for sterilization, storage, potting, harvesting, and photography, special instrumentation, and equipment and space for nutrient-culture work will be provided.

* * *

Atomic Energy of Canada Limited is planning early construction of a large-scale atomic power station, at an estimated cost of about $60 million, exclusive of design and development costs. The site has not yet been selected. The station will probably be completed and in operation by late 1964 or early 1965. Known as CANDU (Canadian Deuterium Uranium), the power station will produce 200,000 kilowatts of electricity and will use a natural-uranium heavy-water system.

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Ten secondary schools in the United States have been cited by the American Association of Physics Teachers for excellence in the teaching of physics. They are as follows: John Burroughs School, St. Louis, Mo.; Bronx High School of Science, New York, N.Y.; Chamblee High School, DeKalb County System, Chamblee, Ga.; Corvallis Senior High School, Corvallis, Ore.; South High School, Denver, Colo.; Phillips Exeter Academy, Exeter, N.H.; Evanston Township High School, Evanston, Ill.; Green River High School, Green River, Wyo.; North Phoenix High School, Phoenix, Ariz.; Washington–Lee High School, Arlington, Va.

* * *

Annual Reviews, Inc., of Palo Alto, Calif. announces the organization of a new series of reviews: the *Annual Review of Pharmacology.* The first volume is scheduled to appear in April 1961. Windsor C. Cutting of Stanford University has been appointed editor and Henry W. Elliott of the University of California, associate director. Members of the editorial committee, under whose direction the reviews will be organized, are as follows: Windsor C. Cutting (chairman); Bernard B. Brodie, National Heart Institute; Maynard B. Chenoweth, Dow Chemical Company; Louis S. Goodman, University of Utah; G. B. Koelle, University of Pennsylvania; Chauncey D. Leake, Ohio State University; and Maurice H. Seevers, University of Michigan.

* * *

A center for nuclear technology will be established at Cornell University this fall. A National Science Foundation grant of $475,000 assured construction of the center, which will include a nuclear reactor unit that can be used for both research and training. The entire project will cost $1,550,000. The center will be under the direction of Trevor R. Cuykendall and David D. Clark of Cornell's department of engineering physics. The nuclear unit includes a zero power core for research, obtained under the National Science Foundation grant, and a training core called a TRIGA (*training research isotope general atomics*) toward the cost of which $150,000 has been granted by the Atomic Energy Commission. TRIGA will also be used in studies involving radioactive isotopes.

* * *

The Atomic Energy Commission plans to issue a permit to the State College of Washington for construction of a water-cooled and water-moderated pool-type reactor on the campus at Pullman. There will be laboratories and equipment for research on radiation effects and for instruction in nuclear science and engineering. The college plans to use the facility for a series of experiments on the uses of radioactivity in agriculture and biology and for experiments demonstrating the basic principles of reactor physics.

* * *

A committee of the National Academy of Sciences–National Research Council has recommended a set of procedures for the disposal of radioactive wastes from nuclear-powered ships that would permit the operation of a fleet of 300 such vessels without undue hazard to human health from marine contamination. The recommendations are contained in a report of the committee on the effects of atomic radiation on oceanography and fisheries, part of the Academy's continuing study of the biological effects of atomic radiation. The report,

"Considerations on the Disposal of Radioactive Wastes from Nuclear-Powered Ships into the Marine Environment," may be obtained from the Printing and Publishing Office, National Academy of Sciences–National Research Council, 2101 Constitution Ave., NW, Washington 25, D.C.

## Grants, Fellowships, and Awards

*Geography.* The National Academy of Sciences–National Research Council will conduct, in 1960, under the financial sponsorship of the Office of Naval Research, its fifth annual program of geographical field research in foreign areas. During the first 4 years awards were made to 37 young Americans to conduct field research for periods ranging up to 20 months. The objective of the program is to stimulate greater participation by young Americans in field research in areas outside the English-speaking areas of North America. Alaska, Hawaii, Canada, Bermuda, and the Bahamas are specifically excluded.

The program is very broad in scope; it includes all branches of geography as well as fields which are closely related to geography. It is designed primarily for graduate students who wish to conduct field research in connection with their doctoral dissertations, but those who received the doctorate within the last few years are also eligible. More established scholars may submit research proposals to the Geography Branch, Office of Naval Research, Washington 25, D.C. The extent of financial assistance will vary according to the need of the individual. The intent is to provide adequately for travel, field, and living expenses. Usually no stipend is provided. Preference will be shown those who plan field investigations of at least 6 months' duration; investigations of a year or more are preferred. Recipients must agree to submit a detailed report of their investigations, suitable for publication, to the Academy–Research Council.

Applications for support of field work to be initiated before 1 April 1961 must be submitted prior to 1 December 1959. Notices of acceptance or rejection will be sent as promptly as possible, probably by the end of December 1959. All applications or requests for further information should be addressed to: Foreign Field Research Program, Division of Earth Sciences, 2101 Constitution Ave., NW, Washington 25, D.C.

*Medical sciences.* The University of Rochester has established a program of postdoctoral fellowships to be awarded graduates of approved medical schools to enable them to pursue research in any of the departments of the School of Medicine and Dentistry. The Buswell fellowships are made possible by the bequest of the late Ralph Hochstetter and are intended to assist well-qualified doctors of medicine to prepare adequately for academic careers.

Buswell junior fellowships will be awarded to medical graduates who have completed at least 1 year of internship or equivalent training. Research experience is not required, but interest and ability are essential, since junior fellows are expected to spend about 90 percent of their time in research or in advanced study in preparation for research. These fellowships will provide a basic stipend of $4500 to $6000 per year, depending upon training and experience, and may be renewed with increments for a second or third year. An additional sum of $500 per year may be provided for each dependent.

Buswell senior fellowships will be awarded to medical graduates who have held a Buswell junior fellowship for 2 or 3 years or who have had comparable experience in medical research and wish to continue in an academic career. These fellowships will provide a basic stipend of $5500 to $8000 per year, depending upon training and experience, with provision for annual increments. An additional sum of $500 per year may be provided for each dependent.

Applications may be submitted at any time. Awards will be announced periodically. Additional information and application forms may be obtained from the chairman of the Committee on Buswell Fellowships, Department of Medicine, University of Rochester Medical Center, 260 Crittenden Blvd., Rochester 20, N.Y.

*Mental health.* The Foundations' Fund for Research in Psychiatry announces that 15 October 1959 is the next deadline for receipt of applications for research fellowships in psychiatry, psychology, sociology, neurophysiology, and other sciences relevant to mental health. Applicants for fellowships should have completed their doctoral training and should preferably have had several additional years' experience in research.

The Foundations' Fund also makes grants in support of research in the area of mental health. Applications for research grants-in-aid should be filed not later than 10 December 1959.

Persons interested in research fellowships or in research grants-in-aid should write for details to: Foundations' Fund for Research in Psychiatry, 251 Edwards St., New Haven 11, Conn.

*Neuromuscular diseases.* The Sister Elizabeth Kenny Foundation is continuing its program of postdoctoral scholarships to promote work in the field of neuromuscular diseases. These scholarships are designed for scientists at or near the end of their fellowship training in basic or clinical fields concerned with the problem of neuromuscular diseases.

Kenny Foundation scholars will be appointed annually. Each grant will provide a stipend for a 5-year period of $5000 to $7000 a year, depending upon the scholar's qualifications. Candidates from medical schools in the United States and Canada are eligible.

Inquiries regarding details of the program should be addressed to: Dr. E. J. Huenekens, Medical Director, Sister Elizabeth Kenny Foundation, Inc., 2400 Foshay Tower, Minneapolis 2, Minn.

*Petroleum.* Grants and awards for advanced study and fundamental research in any field of pure science which may afford a basis for subsequent research directly connected with the field of petroleum are made by the American Chemical Society from the Petroleum Research Fund. This relatively new program is now well established and has made grants in partial support of research in chemistry, chemical engineering, physics, geology, geochemistry, geophysics, bacteriology, mathematics, metallurgy, oceanography, biochemistry, and biophysics.

During 1959–60, approximately 225 grants and awards totaling about $1,570,000, will be in effect, the largest number being in the field of chemistry. More proposals from geology, physics, and other disciplines which may make a fundamental contribution to the field of petroleum would be welcome.

At the present time six types of grants are being made.

1) Grants-in-aid to support projects of fundamental research in the petroleum field. These are primarily for faculty–graduate-student research. They are generally made for 2- and 3-year periods, with 2- or 3-year renewals. Undergraduate participation is encouraged.

2) Grants for fundamental research in the petroleum field at the undergraduate level—educational grants to selected staff members of undergraduate departments for research designed

to stimulate student interest in graduate study and improve the qualifications of the grantee. In general these are made on a yearly basis. They provide summer salaries for the principal investigator, stipends for students during the school year and summer months, and modest amounts for supplies and equipment. These grants seldom exceed $3000 per year.

3) Unsolicited and unrestricted grants made to outstanding scientists at educational institutions in recognition of past accomplishments in fundamental research in the petroleum field. Each grant provides $50,000 to enable scientists at or approaching the peak of their productivity to pursue, without restriction and without time limitation, their quest for new knowledge. Nominations for these awards may be submitted to the program administrator of the Petroleum Research Fund.

4) Grants to provide for exchange of scientists and scientific students between American and foreign nonprofit scientific and educational institutions. To date these awards have been made only to scientists with faculty status or to senior members of educational and scientific organizations. The awards provide all or part of the faculty member's salary and travel expenses for a period (3 to 15 months) of advanced study and research abroad.

5) Grants to teachers in undergraduate departments designed to allow them to obtain, at an institution of higher learning in the United States, a year of advanced study in any of the sciences basic to the petroleum field. The grants made to date have covered a full year's study.

6) Grants to outstanding recent recipients of a doctor's degree for a year of postdoctoral research in the petroleum field. Since 1954 eight such fellowships have been approved and administered through the National Research Council as part of its regular postdoctoral fellowship program.

A 19-man advisory board of The Petroleum Research Fund meets three times annually to consider proposals and policy matters. September 15 and December 15 are the next deadlines for consideration of proposals for programs to start in June or September 1960. Requests for further information about these grants and awards should be addressed to: Program Administrator, The Petroleum Research Fund, American Chemical Society, 1155 16th St., NW, Washington 6, D.C.

## New Journals

*Archives of Oral Biology,* J. B. MacDonald, Boston, regional Ed. Pergamon, 4–5 Fitzroy Square, London W.1. Bimonthly. Individual subscribers, $10; others, $17.

*Development Biology,* vol. 1, No. 1, Apr. 1959. M. V. Edds, Jr., Ed. Academic Press, 111 5th Ave., New York 3. vol. 1 (6 issues, 1959), $14.

*Experimental Neurology,* vol. 1, No. 1, Apr. 1959. William F. Windle, Ed. Academic Press, 111 5th Ave., New York 3. vol. 1 (6 issues, 1959), $16.

*International Atomic Energy Agency Bulletin,* vol. 1, No. 1, Apr. 1959. International Atomic Energy Agency, Kärntnerring 11, Vienna 1, Austria.

*International Journal of Radiation Biology and related studies in Physics, Chemistry and Medicine,* vol. 1, No. 1, Jan. 1959. W. M. Dale, Ed. Academic Press, 111 Fifth Avenue, New York 3.

*Journal of Biochemical and Microbiological Technology and Engineering,* vol. 1, No. 1, Feb. 1959. E. M. Crook, Ed. Interscience, 250 Fifth Avenue, New York 1. Quarterly. $15.

*Journal of the Faculty of Medicine—Baghdad,* vol. 1, (new series), No. 1, Jan. 1959. F. S. Nashat, Ed. College of Medicine, University of Baghdad, Baghdad, Iraq. Quarterly. $4.

*Journal of Medicinal and Pharmaceutical Chemistry,* vol. 1, No. 1, Feb. 1959. Arnold H. Beckett, Ed. Interscience, 250 5th Ave., New York 1. Bimonthly. $15.

*Journal of Molecular Biology,* vol. 1, No. 1, Apr. 1959, J. C. Kendrew, Ed. Academic Press, 111 5th Ave., New York 3. Bimonthly. $14.

*Numerische Mathematik,* vol. 1, No. 1, Jan. 1959. F. L. Bauer, Ed. Springer, Heidelberger Platz 3, Berlin-Wilmersdorf.

*Soviet Physics—Solid State,* (*Fizika Tverdogo Tela*), vol. 1, No. 1, Jan. 1959. (Order from American Institute of Physics, 335 E. 45th St., New York 17.) $55; for libraries of nonprofit institutions, $25.

*Tetrahedron Letters,* No. 1, Mar. 1959. H. Stephen, Ed. Pergamon, 122 E. 55th St., New York 22. $20; free to individual subscribers to *Tetrahedron.*

*Egyptian Journal of Botany,* vol. 1, No. 1, 1958. Egyptian Science Association, Tager Building, 1, Sh. Elhamy, Kasr El Doubara, Cairo. Half yearly. $3.

*The Nucleus,* vol. 1, No. 1, June 1958. Arun Kumar Sharma, Ed. Cytogenetics Laboratory, Department of Botany, University of Calcutta, Calcutta 19. Half yearly. $10.50.

*Turkish Journal of Pediatrics,* vol. 1, Nos. 1 and 2, July–Aug. 1958. Ihsan Dogramaci, Ed. Research Institute of Child Health, Hacettepe Parki, Ankara.

## Scientists in the News

VERN O. KNUDSEN, physicist and vice chancellor of the University of California, Los Angeles, has been named chancellor of the university, effective 1 September. He succeeds RAYMOND B. ALLEN, who resigned.

IRVING WOLFF, vice president for research of the Radio Corporation of America Laboratories, will be awarded an Elliott Cresson Medal by the Franklin Institute, Philadelphia, on 21 October.

GEORGE E. ROTH, director of the Dominion X-ray and Radium Laboratory, New Zealand, has been appointed director of the International Atomic Energy Agency's Division of Isotopes. He succeeds YOSHIO FUJIOKA of Japan.

MORTON HAMERMESH, associate director of the physics division at Argonne National Laboratory, has been appointed director of the division. He succeeds LOUIS A. TURNER, who recently became deputy director of the Laboratory.

Lt. Col. JOHN P. RANSOM, bacteriologist with the Army Research Office, Arlington, Va., has been appointed bacteriologist at the Walter Reed Army Institute of Research, Washington, D.C., in the division of immunology.

GERARD F. MULDERS, senior scientific adviser at the Pasadena, Calif., branch office of the Office of Naval Research, has been appointed associate program director for astronomy in the Division of Mathematical, Physical, and Engineering Sciences of the National Science Foundation, Washington, D.C.

DUNCAN HOLADAY, associate professor of anesthesiology at Columbia University College of Physicians and Surgeons, has been appointed professor of surgery and head of the section of anesthesia in the department of surgery at the University of Chicago.

KLAUS FLOREY, chemist, has been appointed director of the section of analytical and physical chemistry at the Squibb Institute for Medical Research.

The following have been appointed to serve 3-year terms on the selection committee for the senior research fellowship program of the National Institutes of Health, Bethesda, Md.

HOWARD C. HOPPS, chairman of the pathology department and pathologist-in-chief of medical branch hospitals at the University of Texas. ELI D. GOLDSMITH, professor of histology and research coordinator at New York University College of Dentistry and professor of histology at the Graduate School of Arts and Sciences. ANTONIO CIOCCO, head of the department of biostatistics at the University of Pittsburgh's Graduate School of Public Health. JOHN B. GRAHAM, professor of pathology at the University of North Carolina. KIMBALL C. ATWOOD, associate professor in the department of obstetrics and gynecology of the University of Chicago.

HOLGAR HYDEN of the Histological Institute, Faculty of Medicine, University of Göteborg, Sweden, will spend two months in the spring of 1960 at the Lerner Marine Laboratory, Bimini, Bahamas, on a Lerner research fellowship.

JOHN W. CROWLEY, JR., has retired as director of aeronautical and space research for the National Aeronautics and Space Administration after 38 years as a research scientist. Crowley received his B.S. degree in mechanical engineering from the Massachusetts Institute of Technology in 1920 and joined the staff of the National Advisory Committee for Aeronautics at the Langley (Va.) Aeronautical Laboratory, in 1921. He served there until 1945 and was, successively, junior aeronautical engineer, head of the flight research section, chief of the aerodynamics division, head of the research department, and acting engineer in charge of the laboratory. In 1945 he was transferred to the Washington headquarters as acting director of aeronautical research, and 2 years later he was appointed associate director for research.

A specialist in the field of aerodynamics, Crowley has served on the President's Scientific Research Board, the President's Special Board of Inquiry on Air Safety, the guided missile committee of the Department of Defense Research and Development Board, and the President's Airport Board.

On 30 June, at a dinner in his honor, Crowley was presented with the NASA Distinguished Service Medal for outstanding leadership in aeronautical science. He is the first recipient of the award. He is succeeded by IRA H. ABBOTT, former deputy director of aeronautical and space research for NASA.

HARRY J. GOETT, of the National Aeronautics and Space Administration's Ames Research Center, has been appointed director of the agency's new Goddard Space Flight Center, effective 1 September.

ROBERT B. AITCHISON, consulting engineer with Linde Co., a division of Union Carbide Corp., will be awarded a John Price Wetherill Medal by the Franklin Institute, on 21 October.

ROBERT W. NEATHERY, director of museum education at the Franklin Institute, Philadelphia, has been appointed director of the institute's museum.

MIGUEL A. XAVIER, former assistant manager of the Advanced Systems Planning Division of Cook Electric Company, Chicago, has been appointed chief engineer of Century Electronics and Instruments, Inc., Tulsa, Okla.

DAVID D. KECK, acting director of the New York Botanical Garden, has been appointed program director for systematic biology in the Division of Biological and Medical Sciences of the National Science Foundation.

NORMAN H. MACKWORTH, psychologist with the Defence Research Medical Laboratories, Toronto, Canada, will join the professional staff of Dunlap and Associates, Inc., Stamford, Conn., on 1 January 1960.

## Recent Deaths

MOACYR E. ALVARO, São Paulo, Brazil; 59; professor of ophthalmology at the Paulista School of Medicine; founder and former president of the Pan American Association of Ophthalmology; 19 July.

GEORGE F. CAHILL, New York; 69; former head of the department of urology at the College of Physicians and Surgeons of Columbia University; 24 July.

DWIGHT E. CLARK, Chicago, Ill.; 49; chairman of the department of surgery at the University of Chicago; noted for his research on the use of radioactive iodine for the treatment of cancer and other diseases of the thyroid gland; 24 July.

CARL L. DAVIS, Baltimore, Md.; 81; former professor of anatomy at the University of Maryland School of Medicine; 13 July.

WILLIAM B. DUNNING, Englewood, N.J.; 85; a founder and professor of dentistry emeritus of the Columbia School of Dental and Oral Surgery, now part of the Columbia-Presbyterian Medical Center; 21 July.

R. B. H. GRADWOHL; 82; founder and first president of the American Academy of Forensic Sciences; editor of *Clinical Tropical Medicine* and of *Laboratory Digest*; 9 May.

FRANZ R. MOEWUS, Miami, Fla.; 51; botanist with the Applied Research Laboratories, Hialeah, Fla.; a native of Germany, he lectured on genetics and plant physiology at the University of Heidelberg from 1941 to 1951; 30 May.

CLIFFORD C. NESSELRODE, Kansas City, Kan.; 80; a founder of the American Cancer Society and its president in 1948; former president of the Kansas Medical Society; 18 July.

BERNARD SAMUELS, New York; 80; professor emeritus of ophthalmology at Cornell University Medical College; helped establish the Institute of Ophthalmology of the Americas at the New York Eye and Ear Infirmary in 1956; coauthor with Adalbert Fuchs of *Clinical Pathology of the Eye*; 26 July.

ARTHUR STEINDLER, Iowa City, Iowa; 81; distinguished service professor emeritus of orthopedic surgery at the State University of Iowa; 21 July.

GEORGE TARTIKOFF, New York; 45; clinical instructor in obstetrics and gynecology at the College of Medicine, State University of New York, Downstate Medical Center, Brooklyn; 22 July.

EDWARD F. WATSON, Port Chester, N.Y.; 66; retired assistant director of telegraph, signaling, and special systems development of the Bell Telephone Laboratories, New York; holder of 65 patents; 23 July.

*Erratum*: In the news article, "More seismic research asked to improve atomic test detection" [*Science* 130, 26 (3 July 1959)], the second figure in column 2 of Table 1 should have been 1500, not 20–100.

# Book Reviews

**Histoire générale des sciences.** vol. 2, *La Science moderne (de 1450 à 1800)*. René Taton, Ed. Presses Universitaires de France, Paris, 1958. vii + 800 pp. Illus.

This is the second of three projected volumes surveying the history of science. Fortunately, it maintains the same high standards of style and accuracy set by the first volume. In terms of subjects and periods covered it should perhaps be compared with the works of A. Wolf. [*A History of Science, Technology, and Philosophy in the 16th and 17th Centuries* (London, ed. 2, 1950), and *A History of Science, Technology, and Philosophy in the Eighteenth Century* (London, ed. 2, 1952)]. On the whole, it is superior to Wolf's two volumes, particularly as to accuracy, but the reader will still want to have the nice collections of illustrations included in the Wolf volumes, and he will still find useful the attention paid by Wolf to technology and philosophy.

For a volume so complex as this volume of the *Histoire générale*, a résumé of the organization is helpful. The book is divided into three principal parts: "Renaissance," "Seventeenth century," and "Eighteenth century." A shorter fourth part, on the sciences outside of Europe, has been added. Within each of the main divisions there are topical subdivisions. After a brief introduction, by P. Delaunay, on some general aspects of the Renaissance, there are three master chapters, by A. Koyré, on the exact sciences in the Renaissance. The natural sciences in the Renaissance are treated in five later chapters—three by Delaunay on human biology (medicine, zoology, and geology, respectively); one by M. Daumas on chemistry; and one by A. Davy de Virille on botany. The second principal part is introduced by a chapter on the general character of the scientific revolution, by R. Lenoble. This is followed by J. Itard's survey of mathematics from symbolic algebra to the infinitesimal calculus and by a chapter on 17th-century mechanics, by R. Dugas and P. Costabel; one on observational astronomy, by G. Walusinski; one on mathematical optics, by M. A. Tonnelat; one on magnetism and electricity, by Lenoble; and one on chemistry, by Daumas. Natural sciences in the same period (the 17th century) are treated in four chapters: by E. Guyénot, on biology; L. Dulieu, on medicine; Davy de Virille, on botany; and R. Furon, on geology.

The third principal part, covering the 18th century, follows a similar topical arrangement: Dugas and Costabel, Tonnelat, and Daumas continue into the 18th century the treatment of their respective subjects. In addition, C. Morazé has prepared an introductory chapter, while Taton has added a chapter on mathematics; J. Lévy, one on astronomy; Costabel, one on accoustics; G. Allard, one on heat; and E. Bauer, one on electricity and magnetism. This third part concludes with five chapters on the natural sciences: by J. Rostand, on the crucial biological problems of the century; G. Canguilhem, on animal physiology; Dulieu, on medicine; Davy de Virille, on botany; and Furon, on the geological sciences. The fourth and last principal part of the volume consists of three chapters: one on science in the Far East, by J. Chesneaux and J. Needham; one on Indian science, by J. Filliozat; and one on science in Colonial America, by J. Taton and I. B. Cohen.

There are several points which make this the outstanding survey volume on the period from 1500 to 1800. (i) It is rich in detail. For example, this is the only single volume on the history of science that includes an adequate treatment of the history of mathematics (although I must admit that in treating mathematics separately and not in relationship to the development of the physical sciences, some of the effectiveness of including mathematics in the history of science is lost). (ii) The authors are all experts in their respective fields. This obviously makes for greater accuracy of detail and for accuracy in the reporting of recent research, an advantage that outweighs the loss of unity evident when there is more than one author.

Incidentally, this volume seems less unified stylistically than the first volume, a fact which stems in large part from the extraordinary diversity of subject matter and the consequent diversity of treatment. (iii) The contributors assume that the reader knows some science. In line with this assumption, many of the authors write in some detail about the scientific significance of the developments. Hence, for the most part, the contributors avoid the cardinal sin of most such surveys—inclusion of the names and dates of significant individuals without any clear and just evaluation of their contributions. (To be sure, the cataloging approach is not completely avoided, particularly in the sections on the natural sciences.) (iv) There are good illustrations and indexes. The volume is handsomely, if not fully, illustrated with 48 plates and 36 figures. Subjects and proper names are separately indexed. The inclusion in the same index of the names and dates of the scientists mentioned will be useful to the reader who has no background knowledge of the history of science. (v) The bibliographical references are adequate. A selected list of readings is given at the end of each of the principal parts. Needless to say, these lists vary considerably in completeness and usefulness.

It is inevitable that the reader with specialized knowledge of one or more of the many areas discussed in this volume will want to praise particular discussions or, conversely, to question facts and conclusions in his area of competence. A summary review hardly seems to be the place to discuss these individual topics. I cannot refrain, however, from mentioning the masterful discussion by Koyré of the Copernican revolution. It has become fashionable of late to emphasize Copernicus' lack of mathematical originality. Hence, it is good to have Koyré's reaffirmation of the scientific and philosophic importance of Copernicus' astronomy. I am also tempted to point out that the treatment of Galileo's mechanics, while generally able, contains points that certainly demand discussion, if not modification. Hence, while it is true that Galileo stated one form of the law of falling bodies in 1604 in a letter to Paolo Sarpi, as everyone knows, the reader should be reminded that at that time Galileo was so uncertain about the details of his discovery that he claimed that the conclusion that the distance of fall is directly proportional to the square of the time (a cor-

rect conclusion) can be deduced from the assumption that the velocity of fall is directly proportional to the distance of fall (an incorrect assumption). I also find the discussion of Galileo's treatment of inertia quite inadequate. The only passage discussed at length is the famous passage at the beginning of the "Fourth Day" of the *Discorsi,* wherein Galileo describes projectile motion as taking a parabolic path compounded of uniform inertial motion on a horizontal plane and vertical uniform acceleration. The interesting question is this: How do his views in this passage relate to his often expressed doctrine of circular inertial motion? As I have recently pointed out in my *Science of Mechanics in the Middle Ages,* the two apparently different views of inertia are parts of a single concept of inertia, the horizontal plane being used only where the trajectory of motion is very small in relation to the radius of the earth. Or to put it briefly, the nature of the physical problem of projectile motion allows Galileo to take one further step in abstraction that simplifies the treatment of the problem.

The only major disadvantage of this volume is one that stems from the nature of the genre. As a survey, which includes the work of many contributors in limited space, it does not offer sufficient scope for the thorough treatment of any one line of development. But if survey volumes are desirable and play a role in the spread of knowledge, we can agree that this is an excellent example of the type.

MARSHALL CLAGETT
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*University of Wisconsin*

**A Philosopher Looks at Science.** John G. Kemeny. Van Nostrand, Princeton, N.J., 1959. viii + 273 pp. $4.95.

The philosophy of science is a broad and highly technical field. Kemeny's book is an attempt to survey this field for the "interested layman"—in 263 rather thinly printed pages of text. How much may one expect? It will be enough —more than enough—if the author conveys clearly to the reasonably literate reader some of the basic ideas of the area. The uninitiated reader will indeed get from this book some notion of the difference between factual and formal truth; of the nature of scientific laws and their use in explanation and prediction; of the issues in the mechanism-vitalism controversy; and of several other problems in the philosophy of science.

Unfortunately, Kemeny does not escape paying the price of saying too little about too much. The price is not merely thinness but a certain muddying of the waters. For example, Kemeny explicates the distinction between formal or mathematical truth and factual truth by using as a paradigm formalized, uninterpreted "geometry." In such a system, only the connections between the axioms and theorems are mathematically true, while, since they are uninterpreted, the axioms themselves are neither true nor false. Upon interpretation, by Euclidean or non-Euclidean concepts, the axioms become contingent factual statements. But the symbols of the same system may also be interpreted into arithmetic concepts, like pairs of numbers and equations, and this results, of course, in analytical geometry. In this case, which is not mentioned by the author, the axioms themselves are also necessary, mathematical truths. Should this case occur to the reader (as well it might), he will be puzzled (as well he may be) by Kemeny's flat statement that *all* interpretations of formalized systems are factually true or false. Geometry is a fine illustration for explaining the structure of scientific theories, but it is a confusing one, unless considerable care is used, for explaining the difference between formal and factual truth.

Also, hobby-horse technicalities are sometimes introduced which, for clarity's sake, might better have been suppressed. An otherwise useful discussion of how theories are verified suffers badly from overemphasis on an unexplicated notion of "simplicity" as a criterion for choosing among alternative theories. Though this permits Kemeny to emphasize, rightly, how complex a matter it may sometimes be to confirm any isolated statement, it also leads him to assert on one page that we can always cling to any theory and, on another, that theories may be definitely falsified. This confusion is abetted by an unnecessarily equivocal use of the word *theory.* (Nor is the cause of clarity served by calling the referents of all defined terms "fictions"!) Similarly, the mathematically rather trivial point that a function can always be found to fit any set of data is not relevant to all the grief about determinism. Although Kemeny realizes this, he confusingly clutters up an otherwise elementary exposition by unduly elaborating this point.

Having cavilled this much, let me add that Kemeny's book is refreshingly free of nonsense—of either naive overestimation or obscurantist depreciation of the achievements and limits of science. The "interested layman" will certainly profit from this book, and the confusions created are at least of the kind that stimulate rather than inhibit further study.

MAY BRODBECK
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*University of Minnesota*

**The Canal Builders.** The story of canal engineers through the ages. Robert Payne. Macmillan, New York, 1959. ix + 278 pp. Illus. $5.

The publishers of this book have provided an attractive format and careful proofreading. The author, who has written biographies of Mao Tse-tung, Albert Schweitzer, General Marshall, Charlie Chaplin, and Heinrich Schliemann, has produced a disappointing book.

Payne treats successively but discursively the canals of ancient Mesopotamia and Egypt, of classical Greece and Italy, of medieval Italy and France, and of 18th- and 19th-century England and the United States. There are chapters on the Panama Canal and the Suez Canal, in that order, and there is a final chapter on Russian canals and the St. Lawrence Seaway.

If any subject extending "through the ages" is to be successfully presented in a single book, the author must pursue his subject unswervingly, making every sentence do its full share in carrying the argument forward. In this book, Payne repeatedly deserts his subject to include all sorts of peripheral and frequently unrelated items that he has noted in his reading.

The canal engineers are often neglected in favor of more colorful or better known people. For example, in the chapter on canals in the United States, DeWitt Clinton and the Erie canal occupy six pages, but no engineer connected with the project is named. In all, eight American canals are described, but only three canal engineers are identified; of these, the one most fully discussed is allotted but two paragraphs.

The editor should share responsibility for the careless, and in places ungrammatical, writing; there are many pages of exasperating trivia that could have been removed by a careful editor. The book suffers from numerous absurdities, overstatements, and sweeping generalizations.

In a preface, canals are credited with

a causative role in, among other things, the birth of civilization and the rise of armies, "bureaucracy," and law courts. Mathematics, we are told, grew out of the need to measure water; metallurgy, out of the need for "sharp digging instruments."

The history of technology is a promising and exciting field, in which serious interest is just beginning to develop. A book of this sort does not whet the appetite for more.

EUGENE S. FERGUSON
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**The Western Economy and Its Future as Seen by Soviet Economists.** Richard G. Stolt, Ed. International Film and Publications Company, Montreal, Canada, 1958. 102 pp.

It never hurts to know what our self-chosen rivals think about us, and this digest of recent views is useful for that purpose. The editor has collected together, in magazine format on double-columned pages, a miscellany of translated articles, speeches, and interviews by Soviet economists and political leaders, all of the original articles having been published within the last 2 or 3 years. About two-thirds of the space is given over to the economists, who prophesy the ultimate doom of capitalism with a unanimity strange to Western ears. The remaining space contains statements by Mikoyan, Gomulka, and Khrushchev and includes a large segment of the latter's landmark speech to the 20th Party Congress of the Soviet Union.

Through Soviet eyes we see the West as a group of imperialist nations in the last throes of survival, struggling with each other for foreign markets as dumping grounds for the products of overproduction, forcing labor ever deeper into wage slavery and permanent unemployment, moving from one economic crisis to another, and postponing the inevitable collapse only by intensifying militarism and the cold war. Meanwhile communism flourishes, raising production and living standards at an unprecedented pace, embracing an ever-widening circle of mankind, liberating workers from exploitation, and promoting the cause of peace.

Most of the articles were written during the 1957–58 recession, which promised at that time to be the most severe business setback since the Great Depression. The Soviet economists seized this opportunity to reaffirm the established communist doctrine of progressive worsening of crises, a doctrine that had gone without supporting evidence during the postwar years. The reader may now wonder whether the Soviet economists were not overanxious.

One finds many examples of the tenacity of dogma in the face of contradictory evidence. An interesting case is the following statement by A. Katz of Moscow University (page 7): "It was the war in Korea that halted the development of the 1948–1949 crisis. The fact that the war began in mid-1950 (i.e., after there was a certain upturn in industrial production) does not contradict this conclusion; the big monopolies knew beforehand of the gamble that was being prepared in Korea and already in the first half of 1950 began to extend production, anticipating an increase stimulated by demand of a military nature."

This collection, while useful, would have been more illuminating had a few selections from an earlier period been included. It would also have benefited from further editing. The editor and publisher are poorly identified, and there is no statement explaining the purposes of the volume or the criteria of selection. The translators are anonymous, and the original sources are not documented. The volume is therefore suitable only for casual reading. For more careful study, one should consult the standard scholarly translations, such as those published in the *Current Digest of the Soviet Press.*

G. WARREN NUTTER
*James Wilson Department of Economics, University of Virginia*

**The Hydromedusae of the Atlantic Ocean and Adjacent Waters.** P. L. Kramp. Carlsberg Foundation, Copenhagen, Denmark, 1959. 283 pp. Illus. + plates. Paper, Kr. 60.

This work—the most recent report in the "Dana"-Expeditions series—reflects the considerable experience of its author, a scientist long devoted to the systematics of the Hydrozoa.

The scope of the report is actually somewhat broader than the title implies. The text is divided into three sections. Section A, "Systematic account of the collected species" (74 pages), is for the most part an annotated list of the species collected (56 genera, 77 species) but also includes descriptions of three new species and one new subspecies. Section B, "A survey of the Hydromedusae occurring in the Atlantic Ocean and adjacent water" (129 pages), contains keys to and diagnoses of all families, genera, and species occurring in the area. Most of the more than 300 figures illustrating this section are redrawn from other works and have a tendency to be diagrammatic, but they are, on the whole, adequate. There is some repetition of the material covered in section A. Section C, "Zoogeography" (70 pages), covers ecology as well as zoogeography; the primary breakdown is ecological, while the neritic species are further treated zoogeographically.

As implied in the text, the work is by no means definitive in any one of its several aspects. Nevertheless, it exceeds anything previously published on the subject and is certain to be of considerable value to systematists, ecologists, zoogeographers, and oceanographers alike.

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**Studies in Invertebrate Morphology.** Smithsonian Institution, Washington, D.C., 1959. v + 416 pp. Illus. + plates.

This volume was published in honor of Robert Evans Snodgrass on the occasion of his 84th birthday and is a very fitting tribute to one of the foremost insect morphologists living today. The first chapter is a delightful account of his life and an evaluation of his work, written by Ernestine B. Thurman. It is illustrated by a number of cartoons and nonentomological drawings by Snodgrass and closes with a very characteristic personal note by the artist. Thurman has also compiled a list of 79 papers published by Snodgrass between 1896 and 1958.

The rest of the volume contains 17 papers on various aspects of invertebrate morphology. This is a truly international tribute, since nine of the 29 authors write from eight countries in Europe and Asia, and it is interesting to note that all 29 are associated with educational institutions.

Space does not permit discussion of each paper, but most of them are very fundamental studies of a number of aspects of morphology, defined by Snodgrass as "what you *think* you see with your mind." The papers range from studies of the external anatomy of a

semiaquatic grasshopper (by Carbonell) and of the morphology of the head of Chironomidae (by Gouin) to metachemogenesis (by Rockstein) and a physiological approach to the relation between prey and predator (by Roeder). Other subjects covered are eye pigmentation, the onychophoran head, the first leg segments, spinasternal musculature, the mechanism of feeding in flies and Hemiptera, morphological adaptation, shaping of egg strings in copepods, molecular organization of insect cuticle, the nervous system of a grasshopper, the thoracic musculature of Diptera and moths, and the phylogenetic significance of entognathy.

This is a splendid collection of papers, many of them beautifully illustrated, and the volume is a credit to the authors and to the members of the committee, headed by J. F. G. Clarke, who planned and arranged it.

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## New Books

*Aquarium Book for Boys and Girls.* Alfred Morgan. Scribner's, New York, 1959. 223 pp. $3.

*Bigger's Handbook of Bacteriology.* For students and practitioners of medicine. F. S. Stewart, Ed. Williams & Wilkins, Baltimore, Md., ed. 7, 1959. 621 pp. $8.

*A California Flora.* Philip A. Munz and David D. Keck. Univ. of California Press, Berkeley, 1959. 1681 pp. $11.50.

*Catalytic Models in Epidemiology.* Hugo Muench. Harvard Univ. Press, Cambridge, Mass., 1959. 121 pp. $4.50.

*Elementary Decision Theory.* Herman Chernoff and Lincoln E. Moses. Wiley, New York; Chapman & Hall, London, 1959. 379 pp. $7.50.

*Fluidization.* Max Leva. McGraw-Hill, New York, 1959. 340 pp. $11.50.

*Gmelins Handbuch der Anorganischen Chemie.* System No. 5, *Fluorine,* 1959, 276 pp., $36; System No. 15, pt. C, *Silicium,* 1958, 513 pp., $67.44; System No. 59, pt. D, *Iron,* 1959, 618 pp., $77.04. Verlag Chemie, Weinheim, Germany.

*The Historical Development of Physiological Thought.* A symposium. Chandler McC. Brooks and Paul F. Cranefield. Hafner, New York, 1959. 414 pp. $6.

*Introduction to Mathematical Physics.* William Band, Van Nostrand, Princeton, N.J., 1959. 336 pp. $7.25.

*A Laboratory Manual of* Cryptobranchus Alleganiensis *Daudin.* Hazel Elisabeth Branch. Vantage Press, New York, ed. 2, 1959. 79 pp. $2.95.

*Linear and Stereoregular Addition Polymers: Polymerization with Controlled Propagation.* Norman G. Gaylord and Herman F. Mark. Interscience, New York, 1959. 581 pp. $17.50.

*Man's Journey through Time.* A first step in physical anthropochronology. L. S. Palmer. Philosophical Library, New York, 1959. 199 pp.

*The Mast Cells.* James F. Riley. Livingston, Edinburgh; Williams & Wilkins, Baltimore, Md., 1959. 192 pp. $6.75.

*Mathematics in Physics and Engineering.* J. Irving and N. Mullineux. Academic Press, New York and London, 1959. 900 pp. $11.50.

*Medical Chemistry.* vol. IV. Wiley, New York; Chapman & Hall, London, 1959. 3437 pp. $12. The literature search for this review included the references found under the heading "Barbituric acid" in *Chemical Abstracts* (1907–56) and in *Chemische Zentralblatt* (1897–1944, with the exception of the years 1940 and 1943). Microfilm No. 1720 of the War Department Army Medical Library, which describes more than 200 barbituric acid derivatives that were tested at the I.-G. Farben-Industrie plant, was also reviewed.

*Principles of Biochemistry.* Abraham White, Philip Handler, Emil L. Smith, DeWitt Stetten, Jr. McGraw-Hill, New York, ed. 2, 1959. 1162 pp. $15.

*Principles of Radiation Dosimetry.* G. N. Whyte. Wiley, New York; Chapman & Hall, London, 1959. 131 pp. $7.

*Probability and Related Topics in Physical Sciences.* Mark Kac. With special lectures by G. E. Uhlenbeck, A. R. Hibbs, Balth. van der Pol. Interscience, New York, 1959. 279 pp. $5.60.

*Proceedings of the Fourth Symposium on Magnetism and Magnetic Materials.* Supplement to the *Journal of Applied Physics,* vol. 30, 1959. For the American Inst. of Physics. McGraw-Hill, New York, 1959. 323 pp. $10. This volume contains more than 240 papers written by more than 350 specialists in the field. The papers are presented under the following headings: "Ferrites," "Computer components," "Macromagnetics: domain walls," "Magnetic properties of metals and alloys," "Fine particles," "Amplifiers, microwave applications," "Resonance," "Metallurgical considerations," "Fundamental interactions," "Instrumentation," "Thin films," "Neutron diffraction and irradiation," "Garnets and other compounds." "Anisotropy, other than in thin films."

*Programming Business Computers.* Daniel D. McCracken, Harold Weiss, Tsai-Hwa Lee. Wiley, New York; Chapman & Hall, London, 1959. 527 pp. $10.25.

*Rocket Encyclopedia Illustrated.* John W. Herrick and Eric Burgess, Eds. Aero, Los Angeles 26, Calif., 1959. 607 pp. $12.50. In the preface the editors state that "It has been the policy . . . to collect, in a convenient and understandable reference book, as many as possible of the facts and theories concerning the new technology of rocket propulsion." The entries are alphabetically arranged. Nearly all entries are presented in two parts: a concise definition, in technical phrases that are intended to satisfy the needs of members of the rocket industry, and an explanation which gives more detailed information about the term in language intended to be within the capabilities of a high-school graduate. In the explanation sections, each term that the editors believe might need additional clarification is printed in italics. This signifies that the term is fully defined and discussed in its own alphabetical position in the book.

*Sampling Inspection Tables.* Single and double sampling. Harold F. Dodge and Harry G. Romig. Wiley, New York; Chapman & Hall, London, ed. 2, 1959. 235 pp. $8.

*Servomechanisms and Regulating System Design.* vol. 1. Harold Chestnut and Robert W. Mayer. Wiley, New York; Chapman & Hall, London, ed. 2, 1959. 697 pp. $11.75.

*Solid Propellent and Exothermic Compositions.* James Taylor. Interscience, New York, 1959. 163 pp. $4.25.

*The Structure of Metals.* A modern conception. Iliffe, London; Interscience, New York, 1959. 124 pp. $4. The papers published in this volume were offered as lectures at the annual refresher course of the Institution of Metallurgists (1958). The lectures are "The electron structure of metals" (G. V. Raynor); "Experimental aspects of the electron theory of metals" (J. A. Gatterall); "Dislocations in metals" (A. G. Quarrell); "Seeing dislocations" (J. Nutting).

*Target for Tomorrow.* Space travel of the future. I. M. Levitt. Fleet Publishing Corp., New York, 1959. 328 pp. $4.95.

*The Theory of Elementary Particles.* J. Hamilton. Oxford Univ. Press, New York, 1959. 494 pp. $12.

*Thermodynamics and Statistical Thermodynamics.* John Geldart Aston and James John Fritz. Wiley, New York; Chapman & Hall, London, 1959. 570 pp. $8.25.

## Reprints

*Amusements in Mathematics.* Henry E. Dudeney. Dover, New York, 1958. 258 pp. $1.25.

*The Canterbury Puzzles.* And other curious problems. Henry Ernest Dudeney. Dover, New York, 1958 (reprint of ed. 4). 250 pp. $1.25.

*Fruit Key and Twig Key to Trees and Shrubs.* Fruit key to northeastern trees; twig key to the deciduous woody plants of eastern North America. William M. Harlow. Dover, New York, 1959 (reprint of ed. 1 of *Fruit Key* and rev. ed. 4 of *Twig Key*). 106 pp. $1.25.

*General Homogeneous Coordinates in Space of Three Dimensions.* E. A. Maxwell. Cambridge Univ. Press, New York, 1959 (reprint of ed. 1, 1951). 169 pp. $2.75.

*Mathematical Puzzles of Sam Loyd.* Martin Gardner, Ed. Dover, New York, 1959 (selection of puzzles from *Sam Loyd's Cyclopedia of Puzzles*). 181 pp. $1.

*The Measurement of Power Spectra.* From the point of view of communications engineering. R. B. Blackman and J. W. Tukey. Dover, New York, 1959 [republication of pts. 1 and 2 of "The measurement of power spectra from the point of view of communications engineering," *Bell System Tech. J.,* 37, Jan. and Mar. (1958)]. 190 pp. $1.85.

# Reports

## Use of Phosphorus-32 in Microassay for Nucleic Acid Synthesis in Escherichia coli

*Abstract.* A method was developed to facilitate studies of ribonucleic acid and deoxyribonucleic acid synthesis in growing bacterial cultures of small volume. The nucleic acid fractions were separated by means of a modified Schmidt-Thannhauser procedure applied to micro quantities of $P^{32}$-labeled cells collected on membrane filters. The validity and usefulness of the method are discussed.

There has been a need for a rapid means of following synthesis of ribonucleic acid (RNA) and deoxyribonucleic acid (DNA) in bacterial cultures of small volume. For screening metabolic analogs as inhibitors, and for studying effects of radiation on molecular synthesis, there is an advantage in working with small cultures. Micro techniques involving colorimetric assays have been developed (*1*). By the Keck method, for example, it is possible to detect as little as 0.1 μg of DNA. However, more than $10^7$ *Escherichia coli* cells are then required at the limit of sensitivity, and the increment in DNA in a period of several minutes cannot be determined with any accuracy.

The incorporation of isotopically labeled precursors is a very sensitive criterion for molecular synthesis if the different molecular species can be suitably separated, if the amount of "turnover" is known, and if incorporation can be distinguished from adsorption. The Schmidt-Thannhauser procedure has been used to separate $P^{32}$-labeled bacterial nucleic acids (*2, 3*). Also, an efficient procedure for isolating micro quantities of $P^{32}$-labeled bacterial cells has been developed by Roberts *et al.* (*4*). It seemed practical to combine these two techniques in order to carry out the separation on a micro scale. Phosphorus conservation in bacterial nucleic acids has been demonstrated by many workers and was verified in these studies (*5*) to a maximum 0.5-percent decrease in activity per hour for $P^{32}$-labeled log-phase *E. coli* B in nonradioactive medium. Siminovitch and Graham have shown further that there is no redistribution of $P^{32}$-labeled nucleosides between RNA and DNA (*6*).

*Escherichia coli* B were grown aerobically at 37°C in 10 ml of Tris synthetic medium (*7*). Five microcuries of $P^{32}$-orthophosphate were added when the culture had reached a concentration of $10^7$ cells/cm³ in log phase. The separation procedure was carried out on duplicate 0.2-ml samples taken by pipette from the culture at 4-minute intervals thereafter.

*Step 1.* The 0.2-ml samples were placed in small tubes, and 5 ml of ice-cold 5-percent trichloroacetic acid (TCA) was added to each. The tubes were immediately emptied onto pre-wet filters (*8*) on a suction filtration apparatus similar to that described by Roberts *et al.* (*4*). Then, 5 ml of distilled water was passed through the filters as a rinse. After drying in air, the filters were assayed for radioactivity by a Geiger-Müller counter with a 1.4-mg/cm² mica window. The "TCA-insoluble" fraction thus collected contains phosphorus primarily in RNA, DNA, and phospholipids.

*Step 2.* The filters from step 1 were placed in individual polyethylene cups containing 5 ml of 75-percent ethanol. After 2 hours at room temperature they were again placed on the filtration apparatus and then rinsed with 5 ml of 50-percent ethanol. The alcohol extraction removes over 90 percent of the lipids (*4*). Most of the remainder would be soluble in ether, but this, unfortunately is a solvent for the filter material, so the ether extraction could not be used. The remaining activity on the filters was determined after the filters had dried.

*Step 3.* The filters were next placed in polyethylene cups containing 3 ml of 1*N* KOH at 35°C for 2 hours and then chilled. The RNA was reduced quantitatively to mononucleotides by this step, but the DNA fraction and the filters were dissolved. It was found that the DNA could be quantitatively reprecipitated by the addition of 3 ml of 10-percent ice-cold TCA to each cup. The cups were then emptied on fresh filters on the filtration apparatus, and the filters were rinsed with 5 ml of 5-percent TCA. The activity on the second filters was then determined as the "DNA-residual" fraction, and the activity in the RNA fraction was obtained by subtracting this from the activity after step 2. No appreciable self-adsorption problems were involved in counting the 1.7 Mev beta particles from $P^{32}$. When the elapsed time for the procedure was more than a day, a correction was made for $P^{32}$ decay. Since hot TCA was found to destroy the filter, it was impossible to separate the DNA from the residual fraction on the filters. The residual fraction contains about 2 percent of the $P^{32}$ activity incorporated, and this is distributed in proteins, undissolved phospholipids, and adsorbed phosphorus compounds of low molecular weight.

The extraction procedure was checked by a parallel sampling (1 ml) from the culture, carried through the same extraction procedure in microtubes; centrifugation (11,000*g* for 2 min) was used to collect the precipitates, and the nucleic acids in the different fractions were determined by colorimetric analysis (*1*). The comparison was made on samples from a culture at a concentration of $10^8$ cells/cm³ which had incorporated radioactivity of about 10,000 count/min into the TCA-insoluble fraction. The supernatants were assayed for radioactivity by placing aliquots on planchets for counting. The hot-TCA extraction step from the Schmidt-Thannhauser procedure was used on the microtube samples (*2*). In Table 1 the comparison of $P^{32}$ distributions is shown for three separate runs.

The colorimetric analysis revealed that 94 ± 3 percent of the RNA was recovered in the RNA fraction and that 4 to 5 percent appeared in the alcohol-soluble fraction, but that none appeared in the DNA fraction. Of the DNA, 84 ± 4 percent was recovered in the DNA fraction, 12 ± 3 percent appeared in the RNA fraction, and less than 4 percent appeared in the alcohol-soluble and residual fractions. Since there is 5 to 6 times as much RNA as DNA in the *E. coli* cell, the DNA contamination in the RNA fraction should cause less than 2.5 percent error in that fraction, if the specific activities are approximately the same. At the limit of sensitivity of this check, the RNA contamination in the DNA fraction could cause a maximum of 20 percent error in that fraction, although the actual error is probably less. A comparison of the filtration and centrifugation methods led to the operational definition of the DNA fraction as the DNA-

*Instructions for preparing reports.* Begin the report with an abstract of from 45 to 55 words. The abstract should *not* repeat phrases employed in the title. It should work with the title to give the reader a summary of the results presented in the report proper.

Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to *one* 2-column figure (that is, a figure whose width equals two columns of text) or to *one* 2-column table or to *two* 1-column illustrations, which may consist of two figures or two tables or one of each.

For further details see "Suggestions to Contributors" [*Science* 125, 16 (1957)].

Table 1. Comparison of $P^{32}$ distribution in fractions obtained by centrifugation (C) and by filtration (F) (three separate runs). Values are given as percentage of total activity in the TCA-insoluble fraction.

| Method | Alcohol-soluble | RNA | DNA-residual | DNA |
|---|---|---|---|---|
| C | 17.8 | 69.0 | 13.6 | 11.8 |
| F | 14.3 | 71.5 | 14.6 | 12.6* |
| C | 17.2 | 68.0 | 14.5 | 12.4 |
| F | 14.7 | 72.5 | 12.8 | 10.8* |
| C | 16.2 | 69.0 | 14.8 | 13.4 |
| F | 13.8 | 71.1 | 15.1 | 13.1* |

* Defined in text.

residual fraction minus 2 percent of the total activity in the TCA-insoluble fraction. The validity of this step was further checked by carrying out the procedure on cultures of *E. coli* $15_{T^-}$ in thymine-deficient media (*9*). In confirmation of Cohen's findings, there was negligible incorporation of $P^{32}$ into the DNA fraction, defined as above, in the absence of thymine. Incorporation into the RNA fraction, however, was linear with time under this condition of no DNA synthesis. The separation procedure has been found useful in further studies of "unbalanced growth" in *E. coli*, induced by the action of ultraviolet light (*10*).

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## Leukemogenic Activity of Filtrates from Radiation-Induced Lymphoid Tumors of Mice

*Abstract.* Cell-free filtrates of x-ray-induced lymphoid tumors of strain C57BL/Ka mice have elicited, on injection into newborn isologous hosts, a lymphoma incidence of 15 to 19 percent. In control mice of the same subline, the incidence of spontaneous lymphoma is about 1 percent. No leukemogenic activity could be detected in filtrates from thymi harvested at 2 to 32 days following completion of x-ray treatment. Activity was evident at 64 days and was perhaps somewhat greater at 128 days. Serial cell-free passage of filtrates in newborn $F_1$ hybrid mice resulted in a marked increase in lymphoma incidence (69 percent), coupled with a shortening of the median latency. Supplementary x-irradiation failed to enhance the activity of filtrates after neonatal injection.

In most strains of mice the thymus is essential for the development of lymphatic leukemia and lymphosarcoma, either arising spontaneously or induced by ionizing radiation, hydrocarbons, or estrogen (*1*). In the case of the radiation-induced disease, however, it has been demonstrated that such tumors may develop from nonirradiated cells of thymic grafts implanted into irradiated hosts (*2*). This phenomenon of indirect induction may be interpreted in terms of the existence of a latent subcellular agent, analogous to the filtrable agent of spontaneous mouse leukemia demonstrated by Gross (*3*), which, having been "activated" by radiation, initiates malignant transformation in susceptible lymphoid cells. For the past 5 years, a series of experiments designed to test this possibility has been in progress in our laboratory (*4*).

Lymphoid tumors were induced in C57BL/Ka mice of both sexes by fractionated whole-body x-irradiation (four weekly doses of 168 r each) started at age 33 ± 3 days (*5*). The incidence of disseminated lymphomas resulting from this treatment is 80 to 90 percent, with an average latency of about 200 days (*6*). The animals were sacrificed and autopsied when unquestionable symptoms of the disease became apparent.

Cell-free extracts of the involved tissues were prepared by a modification of Gross' technique (*3*). Thymus, spleen, liver, and lymph nodes were removed and weighed, and iced Locke's solution was added to make a 20-percent suspension. This was homogenized and centrifuged at 7000*g* for 15 minutes. The supernatant was recentrifuged, and the cycle was repeated for a total of four centrifugations. The entire procedure was carried out at 4°C. The final supernatant was passed through a UF fritted glass filter. Impermeability of the filter to cells was ascertained by retention of *Escherichia coli.*

Filtrates were injected in 0.1-ml amounts either subcutaneously or intraperitoneally into C57BL/Ka or reciprocal $F_1$ (C57BL/Ka × BALB/c) hybrid mice of both sexes, aged 16 hours or less. The animals were maintained under standard laboratory conditions and were sacrificed when moribund, or when older than 600 days. Sections of the involved tissues were stained with hematoxylin and eosin. Only typical lymphocytic lymphosarcomas, identical to those arising after irradiation of strain C57BL (*7*), were tallied as "lymphomas."

Filtrates from isologous, x-ray-induced lymphoid tumors yielded ten (17 percent) disseminated lymphomas among 59 long-term survivors of neonatal injection (Table 1). In a second experiment, filtrates from tumor C43, a radiation-induced thymic lymphosarcoma of C57BL mice which has been carried by serial isologous transplantation for the past 7 years, gave a similar tumor incidence, indicating preservation of activity through some hundred successive transplant generations.

The only other neoplasms observed were reticuloendothelial tumors, ovarian tumors, and hepatomas, all of which occurred with about the expected frequency for aged, untreated mice of this strain.

In our subline of the C57BL strain there has been only one spontaneous lymphoma (1.3 percent) in a total of 74 untreated or saline-injected mice of both sexes maintained for 600 days or longer. A group of 25 C57BL/Ka mice injected when newborn with filtrates from isologous, spontaneous reticuloendothelial tumors and hemangiomas, and another group of 24 which had received filtrates from strain AK lymphoid tumors all remained free of lymphoma for over 600 days. Filtrates from normal tissues of C57BL/Ka mice injected into newborn isologous hosts have elicited no lymphomas to date (9 months) (*7a*).

The possibility that supplementary irradiation might be required to bring out the full potential of the latent leukemogenic agent was tested in another experiment. Newborn C57BL/Ka mice received lymphoma filtrate (the controls received saline) at birth, and a single, whole-body x-ray exposure of 200 r given concurrently or at 2, 6, 14, or 30 days of age. The incidence of lymphoma after the combined treatment was reduced to the level resulting from x-ray treatment alone (0 to 8 percent), except in the group irradiated 30 days after filtrate injection (17 percent).

Pooled thymus glands (from strain C57BL mice) obtained at serial intervals (2, 8, 32, 64, or 128 days) after fractionated, systemic irradiation were used for the preparation of filtrates and assayed to determine the time of first ap-

Table 1. Lymphomas in mice inoculated when newborn with filtrates from radiation-induced lymphoid tumors or from irradiated thymus glands.

| Source of filtrate | Net No. of mice | Lymphomas | | Latency (day) | |
|---|---|---|---|---|---|
| | | No. | Percent | Median | Range |
| *Experimental animals* | | | | | |
| X-ray-induced lymphoma | 59 | 10 | 17 | 582 | 253–688 |
| Lymphoma C43 | 26 | 5 | 19 | 449 | 340–551 |
| Thymus glands obtained: | | | | | |
| 2 days postirradiation | 27 | 0 | 0 | | |
| 8 days postirradiation | 21 | 0 | 0 | | |
| 32 days postirradiation | 21 | 0 | 0 | | |
| 64 days postirradiation | 39 | 3 | 8 | | 370, 405,* 618 |
| 128 days postirradiation | 20 | 3 | 15 | | 333, 473, 580 |
| Filtrate-induced lymphoma† (first passage) | 6 | 2 | 33 | | 83, 176‡ |
| Filtrate-induced lymphoma† (second passage) | 13 | 9 | 69 | 202 | 91–336 |
| *Controls* | | | | | |
| Hemangioma | 15 | 0 | 0 | | |
| Reticuloendothelial tumor | 10 | 0 | 0 | | |
| Strain AK lymphoma | 24 | 0 | 0 | | |
| Saline or no treatment | 74 | 1 | 1§ | 565 | |

* Lymphoid tumor used for first passage.
† Assayed in newborn reciprocal $F_1$ (C57BL/Ka × BALB/c) hybrid mice.
‡ Lymphoid tumor used for second passage.
§ Statistical analysis: filtrates from x-ray-induced lymphoma and lymphoma C43 versus controls: $\chi^2$ (corrected) = 17.760; $P < .001$.

pearance of leukemogenic activity. Microscopically identifiable lymphomas *in situ* first appear at about 30 to 50 days after irradiation (*8*). During the first 32 days after x-irradiation the filtrates were devoid of leukemogenic activity. Activity was evident in thymi harvested at 64 days and was perhaps somewhat greater by 128 days. The latency for lymphomas arising in mice injected with the 64- and 128-day filtrates was of the same order as that following injection of filtrates from frankly disseminated tumors.

Serial cell-free passage of a filtrate-induced lymphoma in newborn $F_1$ hybrid mice yielded lymphomas in two of six (33 percent) and in nine of 13 (69 percent) in the first two passages, with latency of 3 to 11 months. On transplantation, these tumors behaved as though they were of hybrid origin; this excludes the possibility that they were produced by contamination of the filtrate with intact tumor cells. Preliminary results of a subsequent cell-free passage indicate persistent activity of the agent.

It appears that cell-free filtrates from x-ray induced lymphoid tumors of C57BL mice can elicit the disease in compatible hosts. Similar results have recently been reported by Gross (*9*) for strain C3H. The active principle has been shown to have the following properties: (i) It is latent in untreated C57BL mice. (ii) Appropriate x-irradiation of the host "activates" it, and it can be recovered from at least some of the resulting lymphoid tumors. (iii) It passes bacterial filters. (iv) It exhibits specificity in that it causes only lymphoid tumors on injection into nonirradiated newborn isologous and compatible $F_1$ hybrid hosts. (v) Its potency is increased on serial passage, as was also noted by Gross (*9*). These characteristics appear to exclude all agents other than viruses and subcellular genetic determinants.

In many of its properties, the x-ray-activated leukemogenic agent bears, at first glance, a striking similarity to the temperate phage-lysogenic bacterial system (*10*). It does not, however, destroy its host cells on activation; instead, it causes them to proliferate more rapidly than normal. Moreover, the activity of "infectious" preparations is not enhanced (indeed, it was diminished) by x-irradiation of the host. Despite such differences, bacterial lysogenesis remains a useful model on which to base further investigations.

The demonstration of a leukemogenic filtrable agent in the cells of radiation-induced lymphoid tumors provides the first evidence directly linking the external carcinogens to viruses or virus-like agents. It thus lends new emphasis to the long-held view that all neoplasms result from such agents. Nonetheless, this thesis will require step-by-step experimental documentation for a variety of neoplasms and external carcinogens.

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18 March 1959

## Biophysical Approach toward Tumor Regression in Mice

*Abstract*. An external electrical source of low magnitude was used in a series of experiments to alter inherent tumor potentials in mice. While no significant increase of tumor growth was noted in the acceleration group, total tumor regressions were obtained in the inhibition group. Preliminary studies with leukemia did not yield significant results.

It has been shown in the human being that a growing fetus or a growing uterine tumor will cause the uterus to be electronegative with respect to the outer abdominal surface (*1*). In the guinea pig and mouse, the tumor is also electronegative (*2*). This supports the many findings that a growing region is electronegative with respect to a slower growing or nongrowing region in the same organism, whether plant or animal (*3, 4*).

In plants, Lund has demonstrated growth acceleration and deceleration by an external potential source (*4*). The studies described here were based on the hypothesis that the growth rate of malignant tumor tissue would respond similarly to an external electrical source (*5*).

A rapidly growing type of tumor was chosen for initial experiments, and various control measures recommended by

the National Cancer Institute were followed. Swiss albino mice equated for sex, age, and body weight were given trocar implants of sarcoma-180, and fur was clipped from the tumor area. Copper or zinc electrodes were covered with sponge rubber, saturated with saline solution, and placed upon the unbroken skin over the tumor area with the cathode at the tumor site for inhibition. In studies of the acceleration of tumor growth the polarity was reversed. Low values of current were used to prevent cautery. The second electrode consisted of a rest or support, made from a saline-solution-saturated sponge to which the animal was secured, the contact being over a large, unclipped ventral area.

In experiment 1, 30 female mice were divided randomly into three equal control, acceleration, and inhibition groups. Electrode leads for the control group were separated to prevent even contact potential from entering as a variable since it could exceed the inherent tumor potential.

Current was applied to test groups for a period of 5 minutes four times daily for 7 days. All mice were sacrificed and photographed, and the tumors were removed and weighed with an accurate laboratory balance. The results appear in Table 1.

Pure direct current was chosen for all but the first experiment. A restraining device was built to handle ten animals simultaneously. The animals were secured on individual insulated rods attached to a polystyrene plate. Each rest was covered by copper and by sponge rubber for electrolyte retention. Over each mouse was placed a plastic saddle containing a rectangular copper electrode covered with sponge rubber saturated in saline solution. Each circuit was separate, with current controlled by a series rheostat.

In the second experiment, only control and inhibition animals were used. They were sacrificed after 7 days, the tumors were removed, and weight and volume determinations were made. The results are also shown in Table 1.

In the third study an acceleration group was added. One tumor in the inhibition group reached a peak in size and then began to decrease as treatment progressed. When it was removed it had the appearance of a thrombus, while the other tumors were shiny, red, and turgescent. On the fourth day of treatment a small white line appeared on the tumor; on the fifth day the line was larger and dark in color. Within the next 48 hours, invagination of the darkened area of the tumor began. Because of this effect, another experiment was conducted, and in order to attempt complete regression the animals were not sacrificed.

Table 1. Summary of data on tumor inhibition and acceleration.

| Item | Experiment 1 | Experiment 2 | Experiment 3 |
|---|---|---|---|
| Location of implant | Axilla | Scapula | Thoracicolumbar |
| Electrode size | Round, 1 in. | ½ by ¾ in. | 1 by 1½ in. |
| Current | 2 ma at 6 v, pulsating d-c | 2 ma | 2½ ma |
| Prior growth of tumor | 24 hr | 78 hr | 48 hr |
| Total time of treatment | ⅓ hr | 15½ hr | 33 hr |
| Mean weight of tumors in controls | 1.7 g | 1.5 g | 0.66 g |
| Standard deviation | 0.6 | 0.5 | 0.11 |
| Mean weight of inhibited tumors | 1.6 g | 1.0 g | 0.41 g |
| Standard deviation | 0.5 | 0.4 | 0.18 |
| Difference probability of inhibition ($t$-test) | < 90 percent | 97 percent | 95 percent (vol.) |
| Mean weight of accelerated tumors | 1.9 g | | 0.58 g |
| Standard deviation | 0.5 | | 0.14 wt. |
| Difference probability of acceleration ($t$-test) | < 90 percent | | < 90 percent |
| Percentage acceleration | 10 | | 12 |
| Percentage inhibition | 6 | 33 | 38 |

Twenty females were given intrascapular implants. The mice were treated for an hour and allowed to rest an hour. Treatment averaged 4.8 hours per day. The mean weight of both control and test groups was 21 g at trocar implant. Treatment began 24 hours after trocar with a current of 3 ma at 3 v.

After 15 days of treatment the tumors were measured with calipers. The mean tumor volume of treated animals was 42 percent of that of the control animals, which was 5.33 $cm^3$.

By the 21st day all control animals had died and a 60 percent total regression of the test tumors had occurred. (*Total regression* means that the tumor had decreased progressively in volume, hardened, and dropped off, leaving a new skin surface at the former tumor site.)

A confirmation study was made with 18 test and 18 control animals 6 weeks old, each weighing about 25 g. A 10-day tumor growth period was allowed.

Test animals were subjected to 3 ma at 6 volts for 3 hours a day with 1 hour rest between test periods. Control animals followed the same regimen except that no current flow was permitted.

Each electrode lead was connected to a "scrambler box" so that the technician could not distinguish between control and test animals. Electrode leads to the control animals "floated" within the "scrambler box" to avoid contact potential effects. Current flow through each test animal was regulated separately by the experimenter. Animals were housed individually in a plastic cage containing wood shavings. Current density time was set for 0.016 ma hr/$mm^2$ of electrode surface area.

As treatment began, the mean volume of both test and control tumors was 3.1 $cm^3$. At 17 days, the mean control tumor volume had increased to 5.7 $cm^3$ and test tumor volume had increased to 4.3 $cm^3$. At 24 days, the mean volume of the control tumors was almost 7 times the mean volume of the test tumors. The seven surviving test animals had complete tumor regression; they have survived for more than a year since trocar and are healthy, active, and free of tumors. On these animals, fur again covered the tumor site by the 50th day. Two of the controls survived 31 days.

In this confirmatory test, not tabulated, a probability of difference of 90.5 percent was found between control and test groups. Regression of tumors in the test animals is considered to be highly significant.

No differences were observed between copper and zinc electrodes. When KCl instead of NaCl was used as the electrolyte all animals died quickly.

In preliminary studies of leukemia induced by intraperitoneal L1210 tumor tissue implant, no appreciable effects were observed, although a 15 percent increase in longevity appeared to occur in the test group.

From our results with nearly 500 mice, it appears that continuation of the studies with other types of tumors is desirable (*6*).

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## X-ray Dosimetry and Contact Microradiography with Color Film

*Abstract.* The effect of x-rays at various voltages and intensities, with monochromatic and polychromatic beams, on Ektachrome daylight and artificial-light film was investigated. The colors were rated according to the Munsell color system and ranged over all the spectrum except red. The color in terms of hue, value, saturation, and chroma was a function of wavelength as well as intensity, and thus the method may be useful in dosimetry as well as in radiography. Microradiographs of metals and wood were remarkable in showing detail not obtainable with conventional black-and-white photographic emulsions.

For some time prior to recent reports of the use of color film to distinguish between radioactive isotopes (*1*) and for registration of electron micrographs (*2*) we have been interested in investigating the possibility of increasing the information provided by contact microradiographs registered on color film beyond that derived with the conventional fine-grained, black-and-white photographic emulsions. Also, in the course of our investigation there appeared a paper by Blum (*3*), describing two types of sensitive coatings which permit registration in arbitrary colors of the action of x- or γ-rays of different wavelengths or of ionizing particles of different energies.

It is the purpose of this report to summarize briefly our experience with Kodak Ektachrome daylight and artificial-light film which we could process.

The action of x-ray beams of varied spectral quality or wavelength distribution (in some instances essentially monochromatic) generated at 40 kv by cobalt, chromium, copper, and molybdenum target tubes on the film alone was studied. Copper and molybdenum radiation at 30, 20, 10, 7, and 5 kv, and at 35 and 30 kv, respectively, was also investigated.

The colors produced were classified visually according to the Munsell color system. Colors ranging from blue, blue-green, green, yellow, yellow-red, and purple-blue to gray were obtained. Red, however, was not obtainable.

The reproducibility of the colors under similar exposure conditions was shown—that is, the reciprocity law holds for color film. However, the method of film storage before exposure, as well as change in x-ray tubes having the same target, seems to have affected the colors somewhat. The artificial-light film produced more saturated colors than the daylight film. For the same value of $E$, the same voltage yielded the same color, while a different voltage yielded a different color. The hue varied more from one target to another at the same voltage and $E$ value in daylight film. The hue remained the same after exposure to radiation from any given target for one kind of film. It was easier to overexpose daylight film than artificial. The color property of value decreased with decreasing $E$. There were greater shifts in value and chroma with decreasing $E$. Sometimes even a change of hue was evidenced. Herein lies the key to the use of color film in the evaluation of x-ray dosage.

With a newly designed camera, x-ray beams from copper and molybdenum targets were transmitted through various metal and wood specimens in contact with color film, and the resulting shadow images were examined for color and resolution of the fine structure of the specimen.

Artificial-light film brought out the phase structure of metals at several of the higher voltages, especially with the copper radiation, with remarkable clarity and with differentiation of composition far beyond that in black-white images. Softer radiation was needed to bring out the structure in the wood specimens. Specimens containing elements of large atomic number seemed to render the film more sensitive in resolving structure when higher voltages were used.

Green and blue-green images were obtained for metal specimens on daylight film, while blue was obtained for metal and wood specimens on artificial-light film.

The processing time is the same as that required in the conventional method of microradiography on black-and-white film, although more manipulation is necessary. Because of the rather large grain size, extensive enlargement of the color microradiographs is not feasible. However, the use of these transparencies as slides is very convenient.

Because of the complex nature of the film and the fact that the formulation is highly confidential and not disclosed by the manufacturer, such problems as the inability to obtain red coloration must be answered with conjecture. Thus, it is possible that the radiation may have destroyed the dye or its carrier. Further, it is also possible that variations from one emulsion lot to another may have been responsible for certain variations in color which were unexplainable. The balancing necessary because of the greater saturation of the yellow dye which is used may also be a contributing factor.

Besides producing encouraging results, indicating interesting and valuable applications in radiography and dosimetry, and even for Laue diffraction patterns made with polychromatic x-radiation, this investigation has opened new areas of research in the field of radiation chemistry and may perhaps contribute to the development of new color-film formulations more specifically adapted to radiation in the x- and γ-ray ranges of the electromagnetic spectrum.

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9 March 1959

## Chromosomal Translocation in Domestic Fowl Induced by X-rays

*Abstract.* The cytological appearance and behavior of an x-ray-induced reciprocal translocation between the first and second chromsome of the domestic fowl is described, and its relevance to the further definition of linkage studies in the fowl is observed.

Although there are possibly better organisms among the vertebrates for cytological and genetical investigations than the domestic fowl, economic considerations have led to its frequent utilization, especially for genetic studies, and a large amount of breeding data has been accumulated. Five autosomal groups and one sex-linkage group, with a substantial number of genes in each group are known (*1*). The cytology of fowl, however, has been said to be less well known than that of other vertebrates (*2*), and the chromosome complement has been variously estimated to be between 40 and 80, with the mode near the latter. If these estimates were correct, the prospects for any cytological correlation of genetic data would be indeed dim. But recent studies utilizing a smear tech-

nique, pretreatments of tissues prior to fixation, and a new killing fluid (*3, 4*) have shown that the fowl carries only 12 chromosomes in the male and 11 in the female. The other elements, designated as microchromosomes by previous investigators, are shown by their origin, their heterochromaticity, their structure, their variablity in numbers (due to fusion or fragmentation or both), and their disappearance at the end of the meiotic cycle to be not chromosomes but elements of an adjuvant nature and function. I have called them chromosomoids (*4, 5*). Thus, the fowl apparently carries a haploid number of six chromosomes which correspond to the six known linkage groups, and it now seems possible and feasible to attempt the association of the linkage groups with specific chromosomes.

This study (*6*), while it has not succeeded in associating a known linkage group with its respective chromosome, indicates the feasibility of such an association and presents a cytological demonstration of a reciprocal chromosomal translocation in the fowl involving the first and second chromosomes.

The fowl sent to us for this study was an S. C. White Leghorn male XP781, 22 months of age when killed, and derived from a project on x-ray induction of genetic variability carried on by I. Michael Lerner, Everett R. Dempster, and Nobuo Inouye at the University of California, Berkeley. The bird was produced from unpedigreed random matings in which the semen was exposed to 1000 r-units per generation in each of four generations. It was suspected of being a carrier of a translocation on the basis of hatching performance of the offspring when it was mated to presumably normal mates. Its offspring, tested in turn in a similar way, were found to segregate for normal and suspected translocation behavior.

The bird was killed by pithing through the palatal aperture and the gonads were removed, sliced, and diced into cubes approximately 5 mm on a side. Tissues were pretreated in distilled water for 10 minutes (*7*) before fixation (*3*). Tubules were then dissected and removed to a slide for smearing with propionic carmine. Tissues which may seem too firm for smearing after prolonged fixation will soften to their original consistency if allowed to remain in a drop of 45-percent propionic carmine on the slide for the length of time it takes one to clean and dry a cover slip for the smear.

The normal meiotic complement of six bivalent chromosomes in the male is shown in Fig. 1*A*. Evidences for the nonchromosomal nature of the other chromatic bodies, though irrelevant to this study, have been indicated (*4, 5*). The position of the centromeres in chromosomes 1 and 2 which are involved in the translocation is indicated by the bend in the J-shaped chromosomes (Fig. 1*A*). Figures 1*B* and 1*C* show chromosomes 1 and 2 associated as a quadrivalent forming a cross with a hole between the short arms subtending their respective centromeres. The short arms of chromosomes 1 and 2 were broken just distal to the centromere, and the fragments were translocated as shown diagrammatically in Fig. 1*D*. The bird is heterozygous for the interchange; both bivalent chromosomes 1 and 2 carry one normal chromosome and one with a translocated segment. During synapsis the translocated segments are of sufficient length to permit pairing, producing the characteristic configuration and quadrivalent association shown in Figs. 1*B* and 1*C* and indicated in the diagram of Fig. 1*D*. The net result of this association is one quadrivalent and four bivalent chromosomes, observed from diplotene to metaphase.

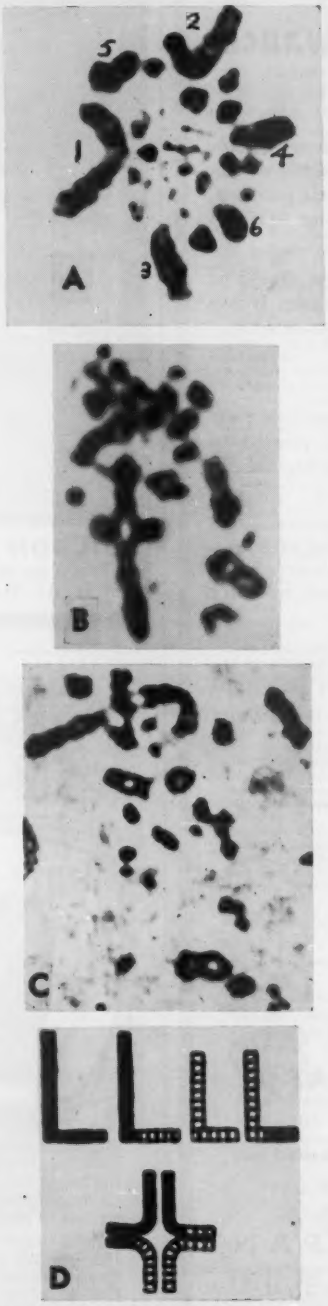


Fig. 1. *A*, Normal meiotic complement of six bivalent chromosomes in the male. *B, C*, Chromosomes 1 and 2 associated as a quadrivalent. *D*, Diagram of translocations.

At the stage of diakinesis, the chiasmata between the interchanges appear to terminalize normally, and regular segregation might be anticipated. However, the chiasmata often either do not resolve or do so belatedly at metaphase, producing an end-to-end association or a cross with short arms. These configurations experience considerable difficulty in anaphase separation, producing bridges and unequal disjunction resulting in heteromorphic daughter nuclei.

Since the chromosomes of the fowl at the second meiotic division are too condensed for detailed morphological study, the results of unequal segregation cannot be adequately followed, but the presence of large masses of abnormal spermatids indicates that the differentiation of spermatids into spermatozoa is partially blocked. Thus it appears that, in addition to the expected semisterility caused by the normal segregation of deficient gametes due to the interchange and crossovers between them, there is an added generational sterility resulting from a partial failure of the chromosomal mechanism. There is also the possibility that, in addition to the segmental interchanges produced by x-rays, other undetectable changes, such as small deletions or inversions, might have occurred, but no cytological evidences for these were found.

EARL H. NEWCOMER

*Department of Botany,*
*University of Connecticut, Storrs*

### References and Notes

1. F. B. Hutt, *Genetics of the Fowl* (McGraw-Hill, New York, 1949).
2. R. Matthey, *Les Chromosomes des Vertébrés* (Library of the University of Lausanne, 1949).
3. E. H. Newcomer, *Science* **118**, 161 (1953).
4. ———, *J. Heredity* **48**, 227 (1957).
5. ———, *Cytologia (Tokyo)*, in press.
6. This investigation was supported by research grant C-3479 from the U.S. Public Health Service.
7. J. Makino and I. Nishimura, *Stain Technol.* **27**, 1 (1952).

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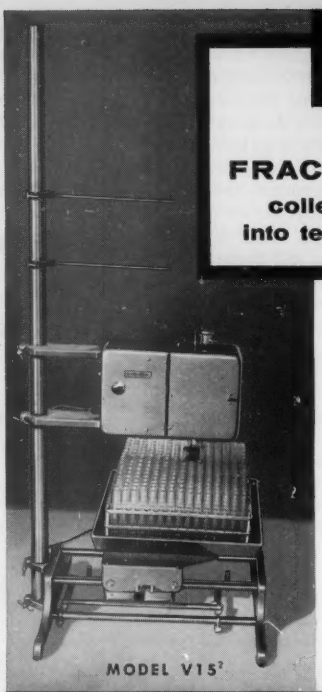


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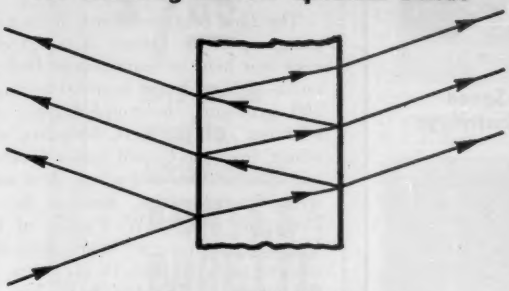

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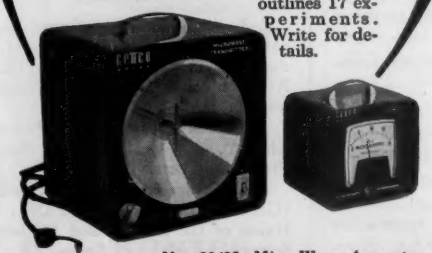

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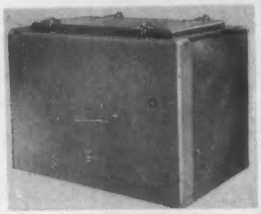

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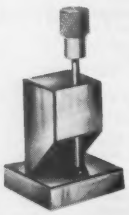

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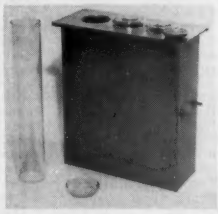

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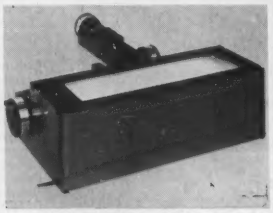

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# Meetings

## Geology Field Conference

The 22nd field conference of the eastern group of the Friends of the Pleistocene was held in southwestern Ontario on 16–17 May. It was attended by nearly 100 geologists, geomorphologists, soil scientists and engineers, botanists, and others, from the United States, Canada, and Europe. One and a half days were spent in field trips, directed by A. Dreimanis and R. W. Packer, of the University of Western Ontario, with discussions at more than 15 exposures. In the evening of 16 May, J. D. Ives reported on his observations in northwestern Labrador-Ungava, where geomorphologic evidences suggest that the last glacial cover was less extensive than the penultimate.

The principal topic of the field conference was late Pleistocene stratigraphy, as outlined by Dreimanis, previously [*Science* **126**, 166 (1957); *Ohio J. Sci.* **58**, 65 (1958)] and at the conference. Preclassical Wisconsin glacial and interstadial deposits were examined along Lake Erie near Port Talbot, and classical Wisconsin drift, including deposits of proglacial lakes (Maumee and younger), through the entire field-trip area from Lake Erie to north of London, Ontario. In addition, considerable time was spent discussing glacial movements, as deciphered by lithologic and fabric studies of tills; the origin of laminations in till; boulder pavements; folding and other deformations in glacial drift; "sedimentary dikes"; origin of leached sand underneath calcareous till; soil formation; and erosion by streams and along lake shores.


A. DREIMANIS

*University of Western Ontario, London, Canada*


## Forthcoming Events

**September**

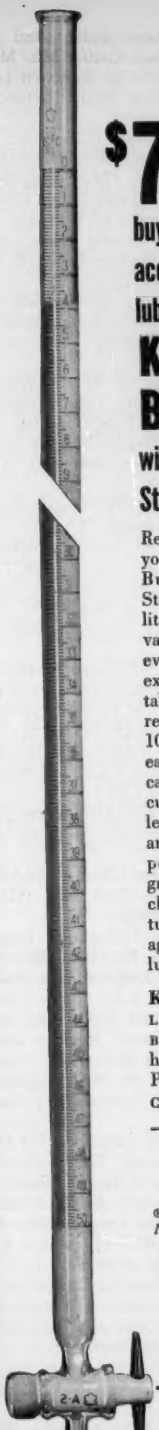
**1–3.** Association for Computing Machinery, natl., Cambridge, Mass. (J. Moshman, Council for Economic and Industrial Research, Inc., 1200 Jefferson Davis Highway, Arlington 2, Va.)

**1–6.** College of American Pathologists, Chicago, Ill. (A. H. Dearing, Suite 2115 Prudential Plaza, Chicago 1.)

**1–7.** History and Philosophy of Science (General Assembly, History Div., Intern. Union of the History and Philosophy of Science), Barcelona, Spain. (R. Taton, IUHPS, 64, rue Gay-Lussac, Paris 5e.)

**1–8.** Acoustics, 3rd intern. cong., Stuttgart, Germany. (E. Zwicker, Breitscheidstrasse 3, Stuttgart N.)

**1–7 Oct.** International Civil Aviation Organization (Meteorological Div.), Montreal, Canada. (ICAO, Maison de l'Aviation Internationale, Montreal.)



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**2–4.** Allergy, 4th European cong., London, England. (British Assoc. of Allergists, Wright-Fleming Inst., St. Mary's Hospital, London, W.2.)

**2–4.** Cryogenic Engineering Conf., Berkeley, Calif. (K. D. Timmerhaus, CEC, Chemical Engineering Dept., Univ. of Colorado, Boulder.)

**2–4.** Crystal Imperfections and the Chemical Reactivity of Solids (Faraday discussion), Kingston, Ontario, Canada. (Faraday Soc., 6 Gray's Inn Sq., London, W.C.1, England.)

**2–5.** American Mathematical Soc. and Mathematical Assoc. of America (joint summer), Salt Lake City, Utah. (E. Pitcher, AMS, Lehigh Univ., Bethlehem, Pa.)

**2–8.** Foundations of Mathematics: Infinitistic Methods, symp., Warsaw, Poland. (A. Mostowski, Dept. of Mathematics, Univ. of California, Berkeley 4.)

**2–9.** British Assoc. for the Advancement of Science, 121st annual, York, England. (Secretary, BAAS, 18 Adam St., Adelphi, London, W.C.2, England.)

**3–4.** Magnesium in Agriculture, symp., Morgantown, W. Va. (D. J. Horvath, Dept. of Animal Husbandry, West Virginia Univ., Morgantown.)

**3–5.** Nephrology, 1st intern. cong., Geneva, Switzerland, and Evian, France. (G. Richet, Hospital Necker, 149, rue de Sevres, Paris 7e, France.)

**3–6.** American Sociological Soc., natl., Chicago, Ill. (D. Young, Russell Sage Foundation, New York 22.)

**3–9.** American Psychological Assoc., annual conv., Cincinnati, Ohio. (R. W. Russell, APA, 1333 16 St., NW, Washington 6.)

**4–7.** International Federation of Surveyors, annual (by invitation), Gracow, Australia. (IFS, 4, Kanaalweg, Delft, Netherlands.)

**5–11.** Application of Radiation Sources in Industry, intern. conf., Warsaw, Poland. (P. Fent, IAEA, Vienna, Austria.)

**6–12.** Standards on a Common Language for Machine Searching and Translation, intern. conf., Cleveland, Ohio. (Secretariat, Center for Documentation and Communication Research, Western Reserve Univ., Cleveland 6.)

**6–12.** World Confederation for Physiotherapy, 3rd intern. cong., Paris, France. (A. Nicolle and J. Dupuis-Deltor, Société d'Organisation des Congrés Français et Internationaux, 1, rue Chanez, Paris 16e.)

**7–9.** Psychometric Soc., Cincinnati, Ohio. (P. H. DuBois, Washington Univ., St. Louis 5, Mo.)

**7–9.** Society of General Physiologists, Urbana, Ill. (F. G. Sherman, Dept. of Biology, Brown Univ., Providence 12, R.I.)

**7–10.** Institute of Management Sciences, Paris, France. (A. S. Manne, Dept. of Economics, Yale Univ., New Haven, Conn.)

**7–11.** American Soc. of Clinical Pathologists, Chicago, Ill. (C. E. Wells, 2052 N. Orleans, Chicago 14.)

**7–11.** Illuminating Engineering Soc., annual natl. conf., San Francisco, Calif. (A. D. Hinckley, IES,, 1860 Broadway, New York 36.)

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*7–12.* World Medical Assoc., 13th general assembly, Montreal, Canada. (WMA, 10 Columbus Circle, New York 19.)

*8–15.* Sociology, 4th world cong., Milan and Stresa, Italy. (Intern. Sociological Assoc., Skepper House, 13 Endsleigh St., London, W.C.1, England.)

*9–10.* Air Pollution, 2nd intern. cong., New York, N.Y. (American Soc. for Mechanical Engineers, 29 W. 39 St., New York 18.)

*9–11.* Applied Mechanics, West Coast conf., Stanford, Calif. (A. B. Conlin, ASME, 29 W. 39 St., New York 18.)

*9–11.* Fiber Attraction and Bending, symp., Appleton, Wisc. (Technical Assoc. of the Pulp and Paper Industry, 155 E. 44 St., New York 17.)

*9–11.* Midwestern Conf. on Fluid and Solid Mechanics, Austin, Tex. (M. J. Thompson, MCFSM, Dept. of Aeronautical Engineering, Univ. of Texas, Austin 12.)

*9–12.* Electron Microscope Soc. of America, 17th annual, Columbus, Ohio. (S. S. Breese, Jr., EMSA, Plum Island Animal Disease Lab., Greenport, L.I., N.Y.)

*10–11.* Great Basin Archaeological Conf., 6th annual, Santa Barbara, Calif. (P. C. Orr, Santa Barbara Museum of Natural History, Santa Barbara.)

*10–11.* International Air Pollution Cong. (American Soc. of Mechanical Engineers), Portland, Ore. (D. B. MacDougall, ASME, 29 W. 39 St., New York 18.)

*10–11.* Meteoritical Soc., 22nd, Cambridge, Mass. (F. B. Riggs, Jr., Smithsonian Astrophysical Observatory, 60 Garden St., Cambridge 38, Mass.)

*10–12.* American Assoc., of Obstetricians and Gynecologists, Hot Springs, Va. (E. S. Taylor, 4200 E. Ninth Ave., Denver 20, Colo.)

*10–12.* American Political Science Assoc., natl., Washington, D.C. (E. M. Kirkpatrick, 1726 Massachusetts Ave., NW, Washington 6.)

*10–12.* Calorimetry Conf., 14th, New Haven, Conn. (D. White, Ohio State Univ., Columbus.)

*11–12.* Pacific Slope Biochemical Conf., Corvallis, Ore. (E. E. Conn, Dept. of Biochemistry, Univ. of California, Davis.)

*11–18.* Tuberculosis, 15th intern. conf., Istanbul, Turkey. (T. I. Gokce, Assoc. Turque contre le Tuberculose, Salime Hatun, Mezarlik Sokak, Taksim, Istanbul, Turkey.)

*13–15.* Medical Progress Assembly, Birmingham, Ala. (H. H. Thomas, 920 S. 19 St., Birmingham.)

*13–18.* American Chemical Soc., 136th, Atlantic City, N.J. (R. M. Warren, ACS, 1155 16 St., NW, Washington 6.)

*13–18.* American Soc. for Testing Materials, 3rd Pacific area natl. meeting, San Francisco, Calif. (R. J. Painter, ASTM, 1916 Race St., Philadelphia 3, Pa.)

*13–20.* International Soc. of Surgery, 18th cong., Munich, Germany. (P. Martin, 141, rue Belliard, Brussels, Belgium.)

*14–16.* Applied Spectroscopy, 6th symp., Ottawa, Canada. (W. O. Taylor, Ontario Dept. of Mines, Parliament Bldgs., Toronto, Canada.)

*14–17.* Comparative Biochemistry of Photoeffector Pigments (plant and animal), symp., Asilomar, Calif. (Miss M. B. Allen, Kaiser Foundation Research Inst., S. 14 St. and Cutting Blvd., Richmond, Calif.)

*14–17.* Fast Reactions in Solution, intern. colloquium, Hahnenklee/Harz (near Göttingen), Germany. (M. Eigen, Max-Planck-Institut für Physikalische Chemi, Göttingen, Bunsenstrabe 10, Germany.)

*14–18.* American Dental Assoc., New York, N.Y. (H. Hillenbrand, 222 E. Superior St., Chicago 11, Ill.)

*14–19.* High Energy Accelerators and Instrumentation, intern. conf., Geneva, Switzerland. (Conference Secretariat, CERN, Geneva 23.)

*14–19.* Treatment of Waste Waters, symp., Newcastle upon Tyne, England. (Wastes Symposium, Public Health Engineering Section, Dept. of Civil Engineering, King's College, Newcastle upon Tyne, 2.)

*18–21.* European League against Rheumatism, cong., Istanbul, Turkey. (H. Kocas, Medical School, Ankara, Turkey.)

*18–25.* International Council for Philosophy and Humanistic Studies (5th meeting of the general assembly), Ann Arbor, Mich. (ICPHS, 19, avenue Kleber, Paris 16e, France.)

*19–22.* Planning of Science, intern. symp., Prague, Czechoslovakia. (Secretary, Intern. Symp. on Planning of Science, Gorkho Manesti 23, Prague 3.)

*19–26.* American College of Gastroenterology, Los Angeles, Calif. (D. Weiss, 33 W. 60 St., New York 23.)

*20–25.* Biological Standardization, 5th intern., Lyon, France. (C. Merieux, 17, rue Bourgelat, Lyon.)

*21–24.* International Dental Federation, 47th annual, New York, N.Y. (IDF, 35 Devonshire Pl., London, W.1.)

*21–25.* Instrument-Automation Conf., 14th annual, Chicago, Ill. (R. T. Devore, Instrument Soc. of America, 313 Sixth Ave., Pittsburgh, Pa.)

*21–26.* Mother-Infant Interaction and Its Relation to Mental Health, Ciba Foundation symp. (by invitation), London, England. (G. E. W. Wolstenholme, Ciba Foundation, 41 Portland Pl., London, W.1.)

*21–28.* Biology of Sardines (FAO world meeting), Rome, Italy. (FAO, Viale delle Terme di Caracalla, Rome.)

*21–3.* Permanent Intern. Assoc. of Road Congresses, quadrennial congress, Rio de Janeiro, Brazil. (PIARC, 43, Avenue du President Wilson, Paris 16e, France.)

*22–24.* Some Aspects of Magnetism, conf., Sheffield, England. (Conference Secretary, Inst. of Physics, 47 Belgrave Sq., London, S.W. 1, England.)

*22–25.* American Roentgen Ray Soc., Cincinnati, Ohio. (C. A. Good, Mayo Clinic, Rochester, Minn.)

*22–26.* Cancer Cytology, intern. conf., Madrid, Spain. (Miss E. L. Hughes, 3007 Salzedo, Coral Gables, Fla.)

*23.* Association for the Advancement of Psychoanalysis, New York, N.Y. (New York Acad. of Medicine, 2 E. 103 St., New York.)

*23–2.* International Film Cong., 13th, London and Oxford, England. (Intern. Scientific Film Assoc., 3 Belgrave Sq., London S.W.1.)


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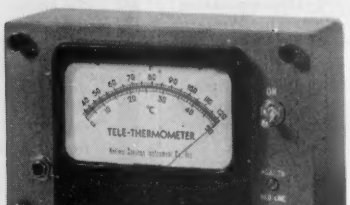


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*24–25.* Solid Propellants Conf. (American Rocket Soc.), Princeton, N.J. (A. F. Denham, ARS, 925 Book Bldg., Detroit 26, Mich.)

*24–26.* American Assoc. of Medical Clinics, Chicago, Ill. (E. P. Jordan, Box 58, Charlottesville, Va.)

*24–26.* American Assoc. for the Surgery of Trauma, Bretton Woods, N.H. (W. T. Fitts, Jr., 3400 Spruce St., Philadelphia 4, Pa.)

*24–26.* Central Assoc. of Obstetricians and Gynecologists, Chicago, Ill. (E. J. DeCosta, 104 S. Michigan Ave., Chicago 3.)

*27–30.* American Inst. of Chemical Engineers, natl., St. Paul, Minn. (F. J. Van Antwerpen, AICE, 25 W. 45 St., New York 36.)

*28–30.* American Oil Chemists' Soc., fall, Los Angeles, Calif. (Mrs. L. R. Hawkins, AOCS, 35 E. Wacker Drive, Chicago 1, Ill.)

*28–30.* Telemetering, natl. symp., San Francisco, Calif. (G. L. Larse, Lockheed Aircraft Corp., Missile Systems Div., Sunnyvale, Calif.)

*28–1.* Recent Developments in Research Methods and Instrumentation, 9th annual symp. and exhibit, NIH, Bethesda, Md. (J. B. Davis, National Institutes of Health, Public Health Service, Bethesda 14.)

*28–2.* American College of Surgeons, 45th clinical cong., Atlantic City, N.J. (R. M. Cunningham, Jr., ACS, 40 E. Erie St., Chicago 11, Ill.)

*30–1.* Industrial Electronics, 8th annual symp., Pittsburgh, Pa. (R. H. Delgado, 954 Brentview Dr., Pittsburgh 36.)

*30–1.* Mississippi Valley Medical Soc., St. Louis, Mo. (H. Swanberg, 510 Maine St., Quincy, Ill.)

### October

*1–4.* American Soc. of Industrial Designers, Asheville, N.C. (Mrs. R. R. Larisch, ASID, 15 E. 48 St., New York 17.)

*1–4.* Electrochemical Thermodynamics and Kinetics, annual intern., Vienna, Austria. (M. P. Van Rysselberghe, CITE for the U.S., Dept. of Chemistry and Chemical Engineering, Stanford Univ., Stanford, Calif.)

*4–7.* American Inst. of Mining, Metallurgical and Petroleum Engineers, fall, Dallas, Tex. (E. O. Kirkendall, AIMMPE, 29 W. 39 St., New York 18.)

*4–9.* Society of Motion Picture and Television Engineers, semi-annual conv., New York, N.Y. (C. S. Stodter, SMPTE, 55 W. 42 St., New York, 36.)

*5–7.* Aeronautical Communications, 5th symp., Utica, N.Y. (L. G. Cumming, Inst. of Radio Engineers, 1 E. 79 St., New York 21.)

*5–7.* Chemical Engineers, annual, Essen, Germany. (Dr. Miessner, VDI-Fachgruppe, Verfahrenstechnik, Rheingaullee 25, Frankfurt-am-Main, Germany.)

*5–7.* National Assoc. of Corrosion Engineers, Northeast regional, Baltimore, Md. (T. J. Hull, NACE, 1061 M & M Bldg., Houston, Tex.)

*5–8.* American Acad. of Pediatrics, Chicago, Ill. (E. H. Christopherson, 1801 Hinman Ave., Evanston, Ill.)

*(See issue of 19 June for comprehensive list)*


# *RADIOACTIVITY AT WORK...#3*

**Our business is radioactivity—applying it, measuring it, protecting against it.**

Applied radioactivity is today's most versatile tool. In this third NSEC report, we focus on a few of the multiplying peacetime uses of radioisotopes and radioactivity.

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*We would welcome the opportunity of discussing how radioactivity can assist you—in studying product or process improvements, reducing manufacturing costs, answering complex research questions.*

**RADIOACTIVE WASTE TREATMENT AND DISPOSAL**

Disposal of the radioactive waste products of a nuclear reactor presents a serious problem. Radioactivity waste differs from ordinary chemical or sanitary refuse in that it cannot be destroyed chemically. Therefore, planning for treatment and storage of wastes must be undertaken in the early stages of reactor design. Under a prime contract with the Atomic Energy Commission, NSEC scientists recently completed a comprehensive survey of all current practices as well as planned techniques for the disposal of highly radioactive waste materials. *NSEC is ready to put its findings to work for those who are planning reactors for power or testing purposes. Ask for our new bulletin which outlines the factors to be considered.*

**WATER TRACING WITH HYDROGEN ISOTOPES**

Ever been confronted with leakage in a system of underground water pipes? This tracing problem has been solved by NSEC scientists using tritium, the radioactive hydrogen isotope. Both tritium and deuterium, a non-radioactive hydrogen isotope, are used in tracking water flow. Often the path of rainwater, underground streams or reservoirs must be traced. NSEC experts conduct assays of the tritium and deuterium content of the water. They measure tritium with a sensitivity of $10^{-5}$ microcuries per milliliter. The detuerium content in water is determined using the density-gradient method. Both these hydrogen isotopes are also used to discover the origin of ground water, thus aiding in water conservation. *NSEC assay services assist in other ways, too, including the biological tracing of organic matter for medical and industrial studies.*

**TESTING FOR SUSTAINED RELEASE OF DRUGS**

A number of pharmaceutical companies are now working to develop a single dosage form of a drug which will be effective over a long period of time: from 12 to 24 hours. The drug, whether capsule, compound or complex, must have a gradual, uniform absorption rate. Its effect must be continuous.

There are many advantages to a prolonged acting drug over a drug which must be taken every few hours. But one of the development problems is *in vivo* testing. How fast is the release rate? Are the peaks and valleys on the absorption curve too pronounced? What is the blood concentration of the drug?

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**NEUTRON DOSIMETRY MEASUREMENT**

In the development and operation of nuclear reactors, it is necessary to know the neutron flux at various points in the reactor. NSEC offers a dosimetry service to determine neutron fluxes—to measure thermal, epithermal, and fast neutrons. NSEC provides the dosimeters, the required analytical services, and a report on flux data. Special fission dosimeters are also supplied, for direct measurement of burn-up occurring in fissionable material during irradiation. NSEC designs and develops techniques for difficult or unusual dosimetery problems. *It's possible to measure neutron flux from the highest now available down to 1 neutron per square centimeter per second.*

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# New Products

*The information reported here is obtained from manufacturers and from other sources considered to be reliable, and it reflects the claims of the manufacturer or other source. Neither* Science *nor the writer assumes responsibility for the accuracy of the information. A coupon for use in making inquiries concerning the items listed appears on page 406.*

■ ENVIRONMENT CHAMBER simulates conditions up to 100 mi altitude. The chamber is 8 ft in diameter and 15 ft long. Pumping system includes line-of-sight cold trapping, a 16-in. diffusion pump, backing pump, and mechanical pump of displacement 48 $ft^3$/min. (Scientific Engineering Labs, Dept. 956)

■ PRESCALER features resolving time of $10^{-8}$ sec for pulse pairs with 15/1 amplitude ratio between successive pulses. Input amplitude required is ±0.2 w minimum into 50 ohm. Discriminator range is ±0.2 to ±6 v and can be set within ±3 percent. An output pulse of 2 v minimum into 50 ohm is furnished for every ten input pulses. Transistor and diode circuitry is used. (Brooks Research Inc., Dept. 965)

■ TEMPERATURE PROBE, for use at flight speeds of Mach 2 and higher, permits measurements to be made while deicing heat is continuously applied. Because the boundary-layer air is continuously removed from the internal flow through the probe, the temperature of the central core of the flow is almost completely independent of the temperature of the housing. Accuracy is said to be within 0.25°C + 0.5 percent of the measured temperature. (Rosemount Engineering, Dept. 968)

■ NEUTRON SURVEY METER uses a detector consisting of a uniform dispersion of zinc sulfide molded into Lucite, the latter serving the dual purpose of supplying proton recoils to produce scintillations in the phosphor and of conducting the light produced to the multiplier phototube. Three linear ranges are 0 to 5, 0 to 50, and 0 to 500 neutrons/$cm^2$ sec. The meter is not sensitive to slow neutrons, and operation is not affected by $Co^{60}$ gamma rays up to 4 r/hr. (Nucleonic Corporation of America, Dept. 970)

■ AUDIOMETER is designed for high-speed screening for hearing loss. The device uses a mixed tone said to combine the frequencies characteristic of human speech in proportions relative to their importance. In operation, the lowest point at which the signal can be heard is recorded. Hearing loss detected by this device is further tested with a pure-tone or other audiometer. (Auralfone Corp., and Tonemaster Manufacturing Co., Dept. 974)

■ FREQUENCY STANDARD is said to be stable to 5 parts in $10^{10}$ per day. The device is transistorized and uses a double proportional-control oven. The unit operates on 24 to 32 v unregulated d-c. Output is 1 v into 5 ohm at 1 Mcy and 100 kcy/sec. A power supply available for operation from 115-v lines has built-in batteries and provides automatic switchover, standby operation for more than 12 hr. The instrument and power supply weigh 9 lb. (James Knight Co., Dept. 971)

■ TEMPERATURE CONTROLLER combines a thermistor sensing element with a transistor amplifier. Range is 0° to 600°F. Setting accuracy is ±2°F within the ambient range 0° to 125°F. Load current capacity is 5 amp for 115 v ac. Operating differential can be as low as 0.4°F. (Fenwal, Dept. 972)

■ CAPACITANCE BRIDGE for measuring small values of direct or grounded capacitance covers the range 0.0002 to 11,000 pf with accuracy said to be ±0.25 percent plus a range factor. Differential capacitance measurements can be read within ±1 part per million on nominal values above 200 pf and conductance 0.01 to 1000 μmho with a test frequency of 100 kcy/sec. A d-c voltage bias is available with adjustment range −5 to +100 v. (Boonton Electronics Corp., Dept. 973)

■ FLOW CALIBRATION STAND for small flow-measuring devices is a volumetric displacement system in which a volume of liquid is measured and timed as it passes through the unit being calibrated and into a collecting chamber. The calibrator employs a free piston operating in a precision-bore glass tube. A groove around the piston is filled with mercury to form a low-friction seal. Flow range is 50 to 5000 $cm^3$/min; accuracy of ±0.2 percent is claimed. (Brooks Rotameter Co., Dept. 976)

■ CLAMP FASTENER UNIT for constructing supporting framework for apparatus and components is made with hole sizes in increments to grip rod, pipe, or armored cable. The unit consists of the clamp and a mounting angle fitted with interlocking teeth spaced to allow angular adjustment in 10-degree steps. The angle and clamp are joined by a bolt that also provides clamping force. (Versa-Lac Corp., Dept. 978)

■ INVERTER CHOPPER, for conversion of direct to alternating current, measures 5/16 by ½ by ⅜ in. Contact closures are hermetically sealed and devoid of organic materials; they operate over the temperature range −65° to +125°C. The driver operates on 6.3-v, 400-cy/sec current. Contacts are rated up to 10 v,

1 ma resistive. Vibration causes less than 10 electrical degrees of contact derangement up to 15 *g* from 10 to 2500 cy/sec. Noise is less than 100 μv r.m.s. (Rawco Instruments, Dept. 983)

■ BTU METER measures quantity of heat transferred to or from chilled or hot water. The instrument operates with a separate water meter and is coupled to the latter by a flexible shaft. Flow is multiplied by temperature differential to determine the amount of heat transferred. Accumulated flow and temperature differential as well as heat transferred are indicated. (American Meter Co., Dept. 982)

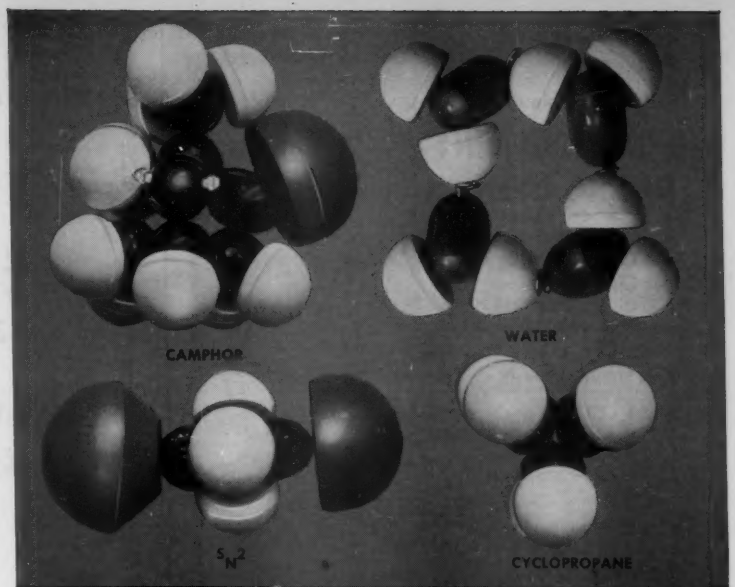
■ PRESSURE TRANSDUCER is a bourdon-tube type with electrical output and without mechanical linkages, bearings, or multiplication. Ranges are 0-to-400 to 0-to-5000 lb/in.$^2$ absolute. Output resistance is 1 to 10 kohm. Static error band is ±0.9 percent. Operating temperature is −65° to +200°F. (Bourns Laboratories, Dept. 981)

■ INFRARED DETECTOR utilizes a zinc-doped germanium photoconductor as the sensitive element. The detector, developed at the Naval Research Laboratory, is sensitive from 2 to 40 μ; peak sensitivity occurs at about 37 μ. The detector is cooled by liquid helium shielded by liquid nitrogen. The cryostat consists of a double Dewar flask; holding time is 24 hr. The time constant of the detector is less than 0.01 μsec. (Perkin-Elmer, Dept. 984)

■ METER-TYPE-RELAY for a-c voltages can be set to make contact at any voltage between 100 and 130 v. Two contacts can be individually set to yield a control differential from 0.5 to 6 v. A built-in power relay handles up to 20 amp. The meter movement uses an aluminum disk suspended in a quadrature field and restrained by hair springs. Temperature effects are compensated to provide less than ± 1 percent calibration drift at temperatures between −20° and +150°F. (Technique Associates, Dept. 995)

■ DIGITAL CLOCK has direct visual read-out display as well as output suitable for actuation of printers, electric typewriters, card punches, and other devices. Time measurement is based on line frequency, but provision is made to slave the clock to an external frequency source or time base. Units that operate at any frequency from 25 to 128 cy/sec can be provided. (Electro Instruments, Dept. 985)

■ STEREOMICROSCOPE provides continuously variable magnification within each of four ranges covering magnifications from 3.5 to 120. Working distance is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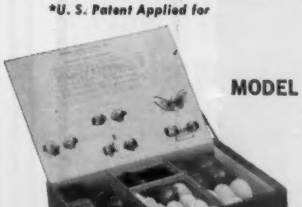

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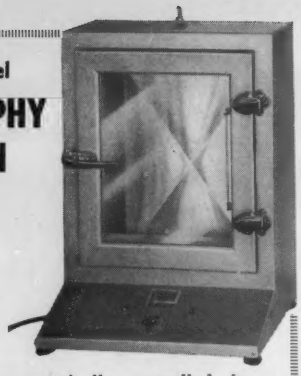

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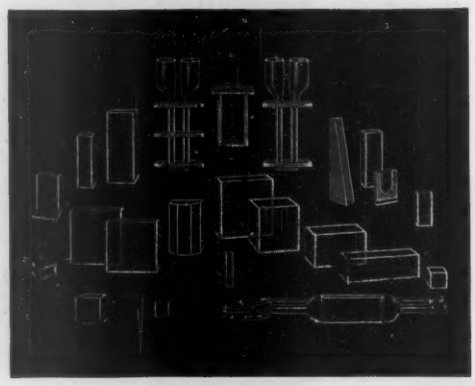

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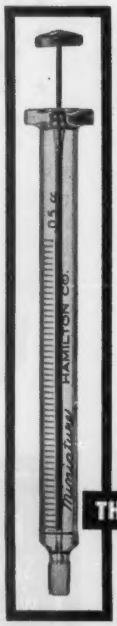

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■ ELECTROMETER of vibrating-condenser type detects currents as small as $10^{-15}$ amp and, with an accessory, measures resistance up to $10^{15}$ ohm. Input ranges are 10, 30, 100, 300, and 1000 mv. Accuracy ranges from ±0.3 percent on the 1000-mv range to ±2 percent on the 10-mv range. Output is 1 ma full scale. Zero is stable within ±100 μv over a 12-hr period. (Electronic Instruments, Dept. 979)

■ ANALOG COMPUTER contains 120 amplifiers, 48 of which are interchangeably summers or integrators, and 16 servomultipliers, each with five ten-turn potentiometers and a slip clutch. Amplifier drift is 25 μv, grid current is less than 30 pa, and noise is 0.25 mv. Automatic time-scale change accelerates solution by two factors of five (Dian Laboratories, Dept. 986)

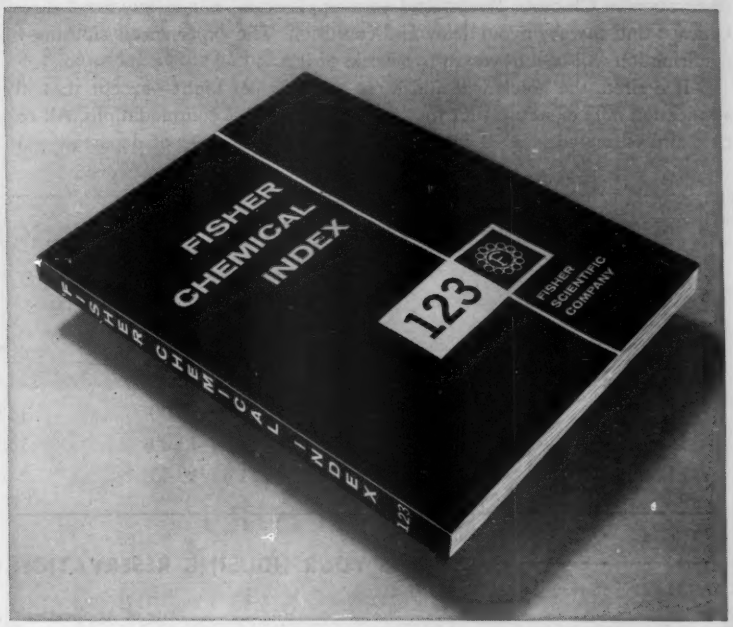
■ SOLAR FURNACE, made for teaching principles of solar energy, can produce temperatures in the vicinity of 2000°F under favorable conditions. The radiation collector is a 14-in. parabolic mirror. A bracket permits the axis of the mirror to be set parallel to the sun's rays. Focusing adjustments are provided. (Strong Electric Corp., Dept. 991)

■ MILLIWATTMETER is a resistive film bolometer measuring power from 1 to 100 mw over the frequency band 8.4 to 10.2 kMcy/sec. Accuracy is ±3 percent. A micrometer adjustment permits a short-circuiting termination to be set for a voltage-standing-wave-ratio near unity at any frequency within the specified range. The temperature change caused by the absorption of incident microwave power by the bolometer film is detected by a thermocouple. (Wayne Kerr, Dept. 994)

■ DRYING TIME INSTRUMENT measures drying time of coatings by drawing a hemispheric needle along a metal specimen strip to which a film of the material to be tested has been applied. Total travel of the needle can be set to occur in 8, 16, or 24 hr. Up to six tests can be run simultaneously. (Eastern Precision Tool and Gage Co., Dept. 992)

■ VIBRATING REED ELECTROMETER detects $10^{-17}$ amp, $6 \times 10^{-16}$ coul, and 0.02 mv from low-impedance sources. Ranges are 10, 100, and 1000 mv and 10 v. Time constant is 0.1 sec with $10^{-10}$ ohm resistor input and proportional to resistance above $10^{-9}$ ohm. The instrument is said to be capable of measuring $C^{14}$ activity to $5 \times 10^{-15}$ c/mg of $BaCO_3$ and tritium activity as low as $10^{-10}$ c/mg. (Applied Physics Corp., Dept. 998)

■ RESONANT REED RELAY is a five-channel device weighing 0.5 oz and measuring ¾ by 1⅜ in. Reed frequencies range from 200 to 500 cy/sec. Minimum driving power is 1.5 mw with stability of ±0.25 percent from 0° to 25°C and ±1 percent from −20° to +80°C. Standard frequency tolerance is 1 percent. Re-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B-100b

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# APPLICATION FOR HOTEL RESERVATIONS

## 126th AAAS MEETING

## Chicago, 26-31 December 1959

The four hotels for the AAAS Chicago meeting have established special low rates and have reserved large blocks of rooms at each level within the price ranges quoted. Thus everyone making room reservations for the AAAS meeting is assured substantial savings. Further, all confirmations will state the room rate assigned.

The list of hotels and their rates and the reservation coupon below are for your convenience in making your hotel reservation in Chicago. Please send your application, *not* to any hotel directly, but to the AAAS Housing Bureau in Chicago and thereby avoid delay and confusion. The experienced Housing Bureau will make assignments promptly; a confirmation will be sent you in two weeks or less.

If desired, the hotels will add a cot at $3.00 per night—except that all children under 12 are free. Mail your application *now* to secure your first choice of desired accommodations. All requests for reservations must give a definite date and estimated hour of arrival, and also probable date of departure.

### AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

For a list of the headquarters of each participating society and section, see page 228, *Science*, 24 July.

**Rates for Rooms with Bath**

| Hotel | Single | Double Bed | Twin Bed | Suite |
|---|---|---|---|---|
| Morrison | $6.50– 9.00 | $9.00–13.00 | $11.00–15.00 | $30.00 and up |
| Hamilton | 6.50– 9.50 | 9.00–13.00 | 11.00–15.00 | 25.00 and up |
| La Salle | 8.00–10.00 | 10.50–13.00 | 12.50–15.50 | 35.50 and up |
| Sherman | 7.45–12.45 | 11.45–16.45 | 14.45–19.50 | 28.50 and up |

### THIS IS YOUR HOUSING RESERVATION COUPON

AAAS Housing Bureau
Suite 900
134 North La Salle Street
Chicago 2, Ill.

Date of Application .....

Please reserve the following accommodations for the 126th Meeting of the AAAS in Chicago, 26–31 Dec., 1959:

TYPE OF ACCOMMODATION DESIRED

Single Room ..... Desired Rate ..... Maximum Rate .....

Double-Bedded Room ..... Desired Rate ..... Maximum Rate ..... Number in party .....

Twin-Bedded Room ..... Desired Rate ..... Maximum Rate .....

Suite ..... Desired Rate ..... Maximum Rate ..... Sharing this room will be:

(Attach list if this space is insufficient. The name and address of each person, including yourself, must be listed.)

.....

.....

First Choice Hotel ..... Second Choice Hotel ..... Third Choice Hotel .....

DATE OF ARRIVAL ..... DEPARTURE DATE .....
(These must be indicated—add approximate hour, a.m. or p.m.)

NAME .....
(Individual requesting reservation) (Please print or type)

ADDRESS .....
(Street) (City and Zone) (State)

*Mail this now to the Housing Bureau.* Rooms will be assigned and confirmed in order of receipt of reservation.

sponse time is approximately 50 msec, dwell time approximately 8 percent, and standard impedance 16,200 ohm. Units are open or hermetically sealed. (Gulton Industries, Dept. 997)

■ PREAMPLIFIER amplifies signals for display on standard cardioscopes and electrocardiographs. Noise level is 1 μv, and 60-cy rejection is $10^6$. The unit operates from a battery and is designed for mounting directly under the edge of the operating table. (Levinthal Electronic Products, Dept. 977)

■ VARIABLE-FREQUENCY POWER SUPPLY furnishes 250 v-amp at frequencies adjustable from 45 to 2000 cy/sec and output voltages adjustable from 0 to 140 v r.m.s. Operation is on 105- to 130-v, 50- to 60-cy/sec power (Itek, Dept. 980)

■ THERMISTOR THERMOMETERS cover the range −328° to +845°F. Accuracy is ±1 percent of scale range and better than 1 percent for short temperature spans. Response time constant is 0.72 sec in liquids and 2.2 sec on surfaces. More than 100 interchangeable probe designs are available. (Will Inc., Dept. 987)

■ CURRENT METER has nine full-scale ranges from 0.1 to 1000 μa d-c. Voltage drop for 0.1 μa full-scale is less than 10 μv across the input. Response time is 5 msec. Basic accuracy of ±0.5 percent is claimed. (Measurements Research Co., Dept. 988)

■ PULSE GENERATOR produces a prepulse and a main pulse with delay variable from 90 mμ sec to 105 msec. The width of the main pulse can be varied over the same range. Repetition rate is variable from 1 cy to 3 Mcy/sec. Rise time of the main pulse is 10 mμsec. (Marconi Instruments, Dept. 990)

■ MULTIPLEXER samples ten separate channels at a rate of 2000 samples/sec per channel. The number of channels, frame rate, and sample rate are crystal-controlled and can be selected with rotary switches on the front panel. The unit can be driven internally or externally. Transistors are used in the plug-in units. (Digital Instrument Laboratories, Dept. 996)

■ CURVE TRACER for transistor characteristics features supply peak sweep currents up to 25 amp, sweep voltages up to 200 v, and bias currents up to 5.6 amp. A family of 8 curves is produced that may be manually or automatically stepped. Internal calibration for both *X*- and *Y*-axes is available. (American Electronic Laboratories, Dept. 999)

JOSHUA STERN
*National Bureau of Standards, Washington, D.C.*


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**Write for detailed information, literature references and prices.**

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- Communications
- Instrumentation
- Experimental physics
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*Visit Aeronutronic's exhibit booth 3822-24 at the WESCON SHOW.*

**Qualified applicants are invited to send resumes and inquiries to Mr. R. W. Speich, Aeronutronic, Dept. 16, Box 451, Newport Beach, California.**

**AERONUTRONIC**

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**Replies to blind ads** should be addressed as follows:
Box (give number)
Science
1515 Massachusetts Ave., NW
Washington 5, D.C.

## POSITIONS WANTED

Medical Mycologist. Ph.D. For research and teaching. Broad experience with fungi, tubercle bacilli, actinomycetes, transduction, genetics. Box 193, SCIENCE. 8/14, 21

Microbiologist; master's degree; would like position involving some teaching with time for research; since 1954, research assistant, large university. Medical Bureau, Burneice Larson, Director, 900 North Michigan, Chicago. X

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Ph.D. or equivalent desired with broad interests in ENZYMOLOGY, METABOLISM and its disorders. Very attractive position in research division of progressive and expanding pharmaceutical firm. Please give detailed résumé of education and experience.

**ETHICON, INC.**

**Route 22 Somerville, New Jersey**

(a) **Biochemist**, Ph.D.; must provide quality control for chemistry procedures, capable of instituting new methods; interested in research and medical education; large general hospital; California. (b) **Microbiologist**, Ph.D; and **Bacteriologist** with master's degree or equivalent; should be qualified to head departments covering all phases of veterinary biological departments; laboratories of large industrial company; medical school city, Midwest. (c) **Organic Chemist**, Ph.D; 5 to 10 years' laboratory experience and **Bacteriologist**, master's degree or Ph.D. to head applications laboratory; opportunity, also, for organic chemist to work on synthesizing of new organic compounds; research department; important company; $12,000–$15,000; East. (d) **Biophysicist**, Ph.D., with excellent training in physics and biology and with competence to carry out independent research to succeed noted scientist retiring after long tenure as research associate, one of leading teaching centers. S8-2 Medical Bureau, Burneice Larson, Director, 900 North Michigan Avenue, Chicago. X

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Several openings for experienced pharmacologists at the Ph.D. level or equivalent.

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*Modern research facilities*
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**Send detailed resume and salary requirements to Mr. E. S. Herlong, Business Manager**

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**New Brunswick, N.J.**

(interviews can be arranged at the Pharmacology Meeting at Miami)

## POSITIONS OPEN

### HISTOCHEMIST

**An expanding midwestern pharmaceutical company has an opportunity for a M.S. histochemist or equivalent in histopathological laboratory of department of pathology. Work involves supervision of laboratory technicians and responsibility of teaching them new techniques. There is opportunity for individual development in histochemical techniques and photomicrographic instrumentation. Please send complete résumé to:**

Technical Employment Coordinator
**The Upjohn Company**
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Ph.D., Pharmacologist. With interest in drug evaluation and pharmacodynamics for position of senior pharmacologist with expanding research department of midwestern pharmaceutical company. Some industrial experience preferred. Send vita and salary record to Box 178, SCIENCE. 7/31; 8/7, 14

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Physicist, M.S. or Ph.D., for radioisotope and metabolic research program of 727 GM&S bed Veterans Administration Hospital affiliated with Indiana University Medical School. Work will consist of metabolic research and biological and medical applications of isotopes. Background in mathematics for dosimetry, body distribution studies, statistics, and knowledge of nuclear instrumentation required. Starting salary $7510 or $10,130 per annum, depending on experience and education. Position is in the Career Civil Service and will be filled through the competitive system. Write Personnel Officer, Veterans Administration Hospital, 1481 West Tenth Street, Indianapolis, Indiana. 8/7, 14

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**14 August 1959**

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Requires no Shielding
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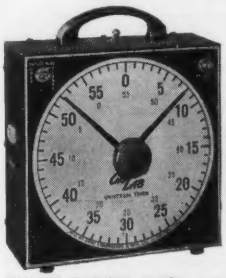

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| *A | C57BL/6 |
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| C3H | DBA/2 |
| *CBA | 101 |
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**Hybrids:**

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Over the past several years our mice have proven to be eminently satisfactory for use in investigations requiring properly inbred mice.

(*We are presently expanding these stocks and they will soon be available.)

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14 August 1959

# *Readers' Service*

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**Use this easy self-mailer to obtain further information about items or literature from the New Products section as well as advertised products.**

## NEW PRODUCTS

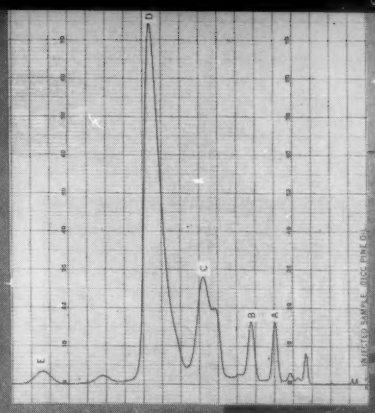
**Circle below desired number corresponding to:**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 956 | 965 | 968 | 970 | 971 | 972 | 973 | 974 |
| 975 | 976 | 977 | 978 | 979 | 980 | 981 | 982 |
| 983 | 984 | 985 | 986 | 987 | 988 | 990 | 991 |
| 992 | 993 | 994 | 995 | 996 | 997 | 998 | 999 |

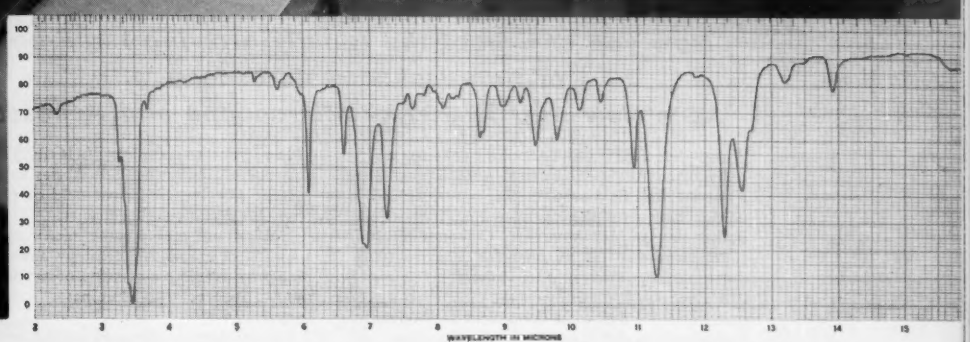
## ADVERTISERS IN THIS ISSUE

In the below list, check page number of advertiser from whom you would like more information. If more than one item appears in ad, letters **A, B, C** are used to indicate particular items available in order of appearance in advertisement. Where more than one ad appears on page, **U** indicates upper ad, **L** lower ad, **I** inside ad, **M** middle ad, and **O** outside ad. The covers are designated by **IFC** (inside front cover), **IBC** (inside back cover), and **OBC** (outside back cover). Advertisements in Personnel Placement are not keyed; only fractional pages (one-sixth or larger) in the Market Place are keyed. A multiplicity of items is indicated by *. Readers are requested to specify on this coupon the particular item in which they are interested; otherwise, the request cannot be processed.

| | | | | |
|---|---|---|---|---|
| ☐ IFC | ☐ 355, A | ☐ 355, B | ☐ 355, C | ☐ 356, A |
| ☐ 356, B | ☐ 357 | ☐ 358 | ☐ 359* | ☐ 360 |
| ☐ 361* | ☐ 362 | ☐ 364 | ☐ 392, O | ☐ 392, UI |
| ☐ 392, LI | ☐ 393, UI | ☐ 393, LI | ☐ 393, O | ☐ 394, U |
| ☐ 394, LO | ☐ 395, I | ☐ 396 | ☐ 397 | ☐ 398 |
| ☐ 399 | ☐ 400, UO | ☐ 400, UI | ☐ 400, LO | ☐ 400, LI |
| ☐ 401 | ☐ 403, A | ☐ 403, B | ☐ 406, LI | ☐ IBC |
| ☐ OBC | | | | |



*Five major components of a 0.01 cc pine oil sample were quantitatively analyzed in 20 minutes using a Beckman GC-2 Gas Chromatograph with Fraction Collector.*




*Although Fraction "A" of the pine oil sample amounted to only 0.0002 cc, the Beckman IR-5 with microsampling accessories positively identified it as dipentene in this 15-minute scan.*

*A new way to analyze complex mixtures*—Quantitative and qualitative analyses can be a matter of minutes with the combination of the Beckman GC-2 Gas Chromatograph and the IR-5 Infrared Spectrophotometer. The GC-2 with Fraction Collector separates the samples...either gas or liquid...into chromatograph-pure fractions as small as 0.0002 cc and provides exact quantitative information. The fractions are then transferred to microcells for positive infrared identification by the IR-5. ⌘ Analyses of complex mixtures and microquantities of material with the gas chromatograph and infrared combination are fast and accurate compared to tedious conventional procedures. Descriptive material and application information that will suggest many uses for this powerful analytical team are available. Write for Data File L-53-38.

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